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SOME EARLY SURGICAL CASES.

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I. THE EDWIN SMITH PAPYRUS.

THE story of the Edwin Smith Papyrus has already been told in the pages of the JOURNAL (1930, xviii, 341, and 1932, xx, 34), but the cases are so interesting that they are worthy of a more careful study from the purely surgical side. The original writer of the papyrus was a surgeon living in Egypt at a time when the Pyramids were being built, probably between 3000 and 2500 B.C. The original work was re-edited in the seventeenth century B.C. by a surgeon who found that many of the terms used had become obsolete. These old terms he interpreted by a gloss and added a commentary explaining what he thought his author had meant to say. The original writer and his editor had the same type of mind as a modern surgeon. They were concerned with facts alone and had no use for magic, charms, or more than the simplest medicines.

The papyrus is a mere fragment, wanting at the beginning and ending abruptly in the middle of a sentence. There is sufficient to show that it was a systematic text-book of surgery dealing with wounds and external injuries, starting with the head and proceeding downwards to the face, neck, and chest. The writer follows a regular plan—first a statement of the injury, then the results of the examination followed by a diagnosis and the appropriate treatment. Some of the injuries he can cure, others he says that he will try to cure, others again he recognizes as fatal, and with these he will have nothing to do. In a true scientific spirit he records the signs and the diagnosis of the injuries for which he considered there was no cure. Care must be taken not to read our own knowledge into the facts, but it seems that he knew something about the action of the heart, something about the brain, and something about the spinal cord. He stitched incised wounds and recognized that the stitches became loose when the wound was healed. He applied a first dressing of fresh meat and afterwards a dressing of honey made up into an ointment. Adhesive plasters he used extensively. Bandaging was a fine art, as may be seen in the wrapping of mummies, and splints he used according to methods which had already become standardized. All the forty-eight cases

are interesting, and the following are selected to illustrate his methods and ideas. It may be noted that the patients were treated sitting up, and not, as is now the custom, in a recumbent posture.

If thou examinest a man with a gaping wound in his head penetrating to the bone and perforating the skull; thou shouldest palpate his wound; shouldest thou find him unable to look at his two shoulders and his breast and suffering with stiffness in his neck. Thou shouldest say regarding him "One having a gaping wound in his head penetrating to the bone and perforating his skull while he suffers with stiffness in his neck. An ailment which I will treat."

Now after thou hast stitched it thou shouldest lay fresh meat upon his wound the first day. Thou shouldest not bind it. Moor him at his mooring stakes until the period of his injury passes by. Thou shouldest treat it afterward with grease, honey and lint every day until he recovers.

To this account in the original text the surgeon who edited the work some seven or eight hundred years later adds four explanations or glosses. He says: (1) "Perforating his skull." It means his skull, a contracted smash, through his incurring a break like a puncture of a jar. (2) "Unable to look at his two shoulders and his breast." It means it is not easy for him to look at his two shoulders and it is not easy for him to look at his breast. (3) As for "stiffness of the neck", it means a lifting up from his having incurred this injury, which has shifted into his neck so that his neck also suffers with it. (4) "Moor him at his mooring stakes." It means putting him on his customary diet without administering to him a prescription. In the light of the context the original writer and his editor seem to mean by this unusual expression "Do nothing, keep him at rest."

There are two cases of fractured base. The first he will try to cure, the second, associated with a depressed fracture, he will not undertake.

Instructions concerning a gaping wound in his head penetrating to the bone and splitting his skull:—

If thou examinest a man having a gaping wound in his head, penetrating to the bone and splitting his skull thou shouldest palpate his wound. Shouldest thou find something disturbing therein under thy fingers and he shudders exceedingly whilst the swelling which is over it protrudes, he discharges blood from both nostrils and from both his ears, he suffers with stiffness in his neck so that he is unable to look at his two shoulders and his breast. Thou shouldest say regarding him; "One having a gaping wound in his head penetrating to the bone and splitting his skull; while he discharges blood from both his nostrils and from both his ears and he suffers with stiffness in his neck. An ailment with which I will contend."

Now when thou findest that the skull of the man is split thou shouldest not bind him but moor him at his mooring stakes until the period of his injury passes by. His treatment is sitting. Make for him two supports of brick until thou knowest that he has reached a decisive point. Thou shouldest apply grease to his head and soften his neck therewith and both his shoulders. Thou shouldest do likewise for every man whom thou findest having a split skull.

The gloss added by the editor explains: (1) "Splitting his skull" means separating shell from shell of his skull while fragments remain sticking in the flesh of his head and do not come away. (2) "The swelling which is over it protrudes" means that the swelling which is over this split is large, rising upward. (3) As for "until thou knowest he has reached a decisive point", it means until thou knowest whether he will live or die he is a case of an "ailment with which I will contend."

A gaping wound of the head with compound comminuted fracture of the skull.

Instructions concerning a gaping wound in his head penetrating to the bone smashing the skull and rending open the brain of his skull :—

If thou examinest a man having a gaping wound in his head penetrating to the bone, and smashing his skull : thou shouldest palpate his wound. Shouldest thou find that smash which is in his skull deep and sunken under thy fingers whilst the swelling which is over it protrudes, he discharges blood from both his nostrils and both his ears and he suffers with stiffness in his neck so that he is unable to look at his two shoulders and his breast. Thou shouldest say regarding him " One having a gaping wound in his head penetrating to the bone and smashing his skull while he suffers with stiffness in his neck. An ailment not to be treated."

Thou shalt not bind him, but moor him to his mooring stakes until the period of his injury passes by.

The gloss adds : As for " smashing his skull ", it means a smash of his skull such that bones getting into that smash sink into the interior of his skull.

Perhaps the earliest reference to the brain is the following :—

If thou examinest a man having a gaping wound in his head penetrating to the bone, smashing his skull and rending open the brain of his skull thou shouldest palpate the wound. Shouldest thou find that smash which is in his skull like those corrugations which form in molten copper and something therein throbbing and fluttering under thy finger like the weak place of an infant's crown before it becomes whole—when it has happened there is no throbbing and fluttering under thy fingers until the brain of his skull is rent open and he discharges blood from both his nostrils and he suffers from stiffness in his neck. Thou shouldest say " An ailment not to be treated." Thou shouldest anoint that wound with grease. Thou shalt not bind it ; thou shalt not apply two strips upon it ; until thou knowest that he has reached a decisive point.

The glosses are somewhat more illuminating than usual : (1) As for " smashing his skull and rending open the brain of his skull ", it means the smash is a large opening to the interior of the skull, to the membrane enveloping the brain so that it breaks open the fluid in the interior of his head. (2) As for " those corrugations which form on molten copper ", it means copper which the coppersmith pours off before it is forced into the mould because of something foreign upon it like wrinkles. It is like ripples of pus.

It is clear from this case that the original surgeon had knowledge of the cerebral membranes and of the cerebrospinal fluid. He had seen the convolutions of the brain during life, perhaps as the result of a wound in battle with a heavy mace.

The next case appears to be one of septic cerebral thrombosis following an injury. It begins :—

If thou examinest a man having a gaping wound in his head, penetrating to the bone and perforating the sutures of his skull thou shouldest palpate his wound although he shudders exceedingly. Thou shouldest cause him to lift his face ; if it is painful for him to open his mouth and his heart is too weary to speak [beats feebly (?)] ; if thou observest his spittle hanging at his two lips and not falling off, whilst he discharges blood from both his nostrils and from both his ears ; he suffers with stiffness in his neck and is unable to look at his two shoulders and his breast. Thou shouldest say concerning him " One having a gaping wound in his head penetrating to the bone and perforating the sutures of his skull ; the cord of his mandible is contracted ; he discharges blood from both his nostrils and from both

his ears while he suffers with stiffness of his neck. An ailment with which I will contend." Now as soon as thou findest that the cord of that man's mandible, his jaw, is contracted thou shouldest have made for him something hot until he is comfortable so that his mouth opens. Thou shouldest bind it with grease, honey and lint until thou knowest that he has reached a decisive point—(that is to say whether he is going to get well or die).

The surgeon then proceeds to give the symptoms which he considers foretell a fatal result :—

If thou findest that the flesh of that man has developed fever from that wound which is in the sutures of his skull, while that man has developed *ty* (meaning of the word unknown) from that wound thou shouldest lay thy hand upon him. Shouldest thou find his countenance is clammy with sweat, the ligaments of his neck are tense, his face is ruddy, his teeth and his back [?] the odour of the chest of his head is like the urine of sheep, his mouth is bound and both his eyebrows are drawn, whilst his face is as if he wept. Thou shouldest say regarding him " One having a gaping wound in his head penetrating to the bone, perforating the sutures of his skull ; he has developed *ty*, his mouth is bound and he suffers with stiffness in his neck. An ailment not to be treated."

If however thou findest that that man has become pale and has already shown exhaustion. Thou shouldest have made for him a wooden brace padded with linen and put into his mouth. His treatment is sitting placed between two supports of brick until thou knowest that he has reached a decisive point.

The next case is also of great interest. It shows that the surgeon had observed the paralysis attending an injury to the brain. The translation reads :—

Instructions concerning a smash in his skull under the skin of his head.

If thou examinest a man having a smash of his skull under the skin of his head, while there is nothing at all upon it, thou shouldst palpate his wound. Shouldest thou find that there is a swelling protruding on the outside of that smash which is in his skull, while his eye is askew because of it, on the side of him having that injury which is in his skull ; and he walks shuffling with his sole on the side of him having that injury which is in his skull.

Thou shouldest account him one whom something entering from outside has smitten, as one who does not release the head of his shoulder fork and one who does not fall with his nails in the middle of his palm ; whilst he discharges blood from both his nostrils and from both his ears and he suffers from stiffness in his neck. An ailment not to be treated.

The treatment is sitting until thou knowest he has reached the decisive point.

The glosses explain : (1) " He walks shuffling with his sole." The surgeon means walking with his sole dragging so that it is not easy for him to walk when it (the sole) is feeble and turned over while the tips of his toes are contracted to the ball of his sole and they (the toes) walk fumbling the ground. (2) " Something entering from the outside." It means the breath of an outside god or death, not the intrusion of something which his flesh engenders. Both the original writer and his editor are trying to distinguish between the results of an injury and of such internal causes as apoplexy or epilepsy which were associated in their minds with demoniac possession.

(To be continued.)

SYMPATHECTOMY AS AN EXPERIMENT IN HUMAN PHYSIOLOGY.*

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Our understanding of the functions of the human sympathetic nervous system is very imperfect, for clinical experience not only reveals gaps in our knowledge, but also casts grave doubt upon many current beliefs. Though it would be deplorable to detract one whit from the honour due to the great physiologists of the past for their early investigations, it is important to realize that the accepted ideas with regard to the workings of the sympathetic system in man have been derived from experiments upon the lower animals, whose nervous system in general, and whose sympathetic system in particular, differ in many respects from the human. It is only since surgery, the most fruitful method of research into the problems of human physiology and pathology, has embraced the sympathetic system, that we have begun to understand something of its activity in man. A great deal has been disclosed already, but surgical experiments take months or even years to yield their results, and it must be remembered that a large number of our present impressions are founded upon incomplete experiments, and the impressions may require considerable revision and modification before they develop into conclusive evidence. Our debt to the physiologists lies in the encouragement and the direction which their animal experiments have given us in recognizing general principles, in devising operative procedures, and in showing how accurate observations may be recorded.

The collection and careful analysis of information obtained by accurate methods of observation of patients, and more especially of patients before and after an operation has been performed upon some portion of the sympathetic system, will bring to light facts which can be proved by no other method of research, and will be the foundation for hypotheses to be tested by further surgical investigation.

Already sympathectomy has been performed for a very large number of diverse conditions, and it would be tedious and unprofitable to summarize what is known about the whole system. I propose to limit myself mainly to the consideration of the value of the operation of sympathectomy in elucidating the physiology of vasomotor control, of intestinal movements, and of micturition, and as a contribution to our knowledge of sensory pathways in the sympathetic system.

VASOMOTOR CONTROL.

Let us consider first the path for vasoconstrictor impulses to the upper extremity. The connector cells lie in the lateral horn of the grey matter of

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* A Hunterian Lecture delivered at the Royal College of Surgeons, February 3, 1933.

the thoracic portion of the spinal cord, from as high as the fourth to as low as the ninth segment. Preganglionic fibres pass from these cells by the white rami communicantes to the ganglionated trunk of the sympathetic, in which they ascend to terminate around the ganglion cells of the middle and inferior cervical and the first and second thoracic ganglia. The inferior cervical and first thoracic ganglia are commonly fused and form the stellate ganglion. In these ganglia lie the excitor cells, whose axons, the postganglionic fibres, run in the grey rami to join the roots of the brachial plexus.

Section of all the grey rami passing to the brachial plexus is a surgical impossibility, and section of the thoracic sympathetic trunk below the second ganglion is unsatisfactory because regeneration can take place, and also because it is probably true to say that peripheral vasodilatation is maximal only if the cells from which the postganglionic fibres originate are removed. The only satisfactory method, therefore, of removing the sympathetic supply to the arm is by ganglionectomy, and the results of the many operations which have now been carried out show that the section of the visceral branches of the ganglia has no appreciable ill effect upon the patient.

The sympathetic supply to the legs has its connector cells in the tenth, eleventh, and twelfth thoracic and the first and second lumbar segments, the preganglionic fibres ending in the lumbar ganglia below the second and in the sacral ganglia. The grey rami from the second lumbar ganglion and the ganglia below it contain postganglionic fibres which are distributed to the periphery by way of the lumbar and sacral plexuses of the spinal nerves. It is therefore clear that excision of the second, third, and fourth lumbar ganglia and the intervening portions of the trunk will mean removal of the excitor cells for the lumbar nerves and division of all the preganglionic fibres to the sacral nerves. In practice this operation seems to provide an adequate degree of vasodilatation even in the foot, though it is probable that to produce full dilatation it would be necessary to remove the sacral ganglia as well, a step which would add very considerably to the difficulty and risk of the operation. It is therefore fortunate that ablation of the sacral ganglia seems to be unnecessary.

Removal of the second, third, and fourth lumbar ganglia involves the section of certain important visceral branches passing from these ganglia to join the aortic, inferior mesenteric, and superior hypogastric plexuses. On this consideration ramisectomy was practised for some time; but as the section of these visceral branches is not a disadvantage to the patient, and may, in certain circumstances, be beneficial, ganglionectomy is now preferred to ramisectomy.

METHODS OF INVESTIGATION.

Sympathetic nerve-fibres have been traced to the minute terminal branches of the vascular system, but the most striking effect of sympathectomy is dilatation of the arteries, and the simplest method of estimating the resultant increase in blood-flow is to record the rise of temperature in the limb. The most accurate temperature records for clinical purposes may be obtained by using copper-constantan thermocouples, which are attached to the skin by adhesive strapping. So that readings may be taken from several

parts simultaneously, the wires from the couples pass through a simple key to the circuit, which includes a mirror galvanometer and a vessel of known constant temperature.

Before an operation for sympathectomy is undertaken it is important to be able to foretell the amount of benefit which is to be expected from it, and various methods of inhibiting or paralysing sympathetic nerves are employed in order to make such a forecast. The peripheral vasodilatation associated with a rise in body temperature is due to inhibition of sympathetic vasoconstrictor impulses, and for experimental purposes the body temperature may be raised either by protein shock or by heating the body in a hot-air bath.

Brown has described the reliance he has come to place upon the first method after several years' experience, more particularly in differentiating organic obstruction of arteries from conditions in which the lumen is narrowed by spasm. He induces fever by intravenous injection of triple typhoid vaccine, and the surface temperature of the fingers and toes is taken simultaneously with the mouth temperature. Normally, after a slight fall, the temperature in the mouth and on the surface rises, the magnitude of the surface rise depending on the initial temperature of the extremity, the severity of the febrile reaction, and the patency of the arteries. If the rise of temperature in the mouth is subtracted from the rise of skin temperature, the figure so obtained will indicate the change in skin temperature due to movement of blood into the extremity as a result of vasomotor changes.

What Brown calls the 'vasomotor index' is determined by dividing the above figure by the rise of temperature in the mouth, i.e.,

$$\frac{\text{surface rise} - \text{mouth rise}}{\text{mouth rise}}$$

and this index is high in cases of vasomotor disease associated with spasm, while in conditions of organic disease in which vasodilatation is impossible the value drops to zero.

In our hands, however, the alternative of warming the body in a hot-air bath, following the plan suggested by Lewis,[1] has given us even more information, we imagine, than could be obtained by protein shock, since the experimental conditions are more directly under our control, and small changes in the behaviour of different digits during vasodilatation may be more accurately observed.

The patient sits in a small chamber made of draught-proof non-conducting material, so arranged that with the coverings open the temperature within may remain about the same as that of the room; but when the chamber is closed, the coverings being made to fit closely at the neck and wrists (or ankles), the temperature within it may be raised rapidly to 50° C. by means of a series of carbon-filament lamps. The hands, previously cooled by immersion for twenty minutes in a water bath at 15° C., protrude from orifices in the coverings and rest upon a small raised platform of wood or cork so as not to come into contact with the chamber itself. The room temperature should be kept low—about 15° C. is probably the optimum—for at higher temperatures vasodilatation might be produced by external warmth, whereas what we wish to determine is the degree of vasodilatation produced

reflexly owing to heating the body. It is an easy matter to raise the room temperature if the effect of direct warming of the skin of the extremities has to be tested, but synchronous readings must be taken of the temperature of the room, of the skin of the extremity, and of the hot-air bath. When these are plotted it is possible to assess the relative importance of the direct effect of external temperature, and of nervous vasomotor reactions, in determining the activity of the peripheral circulation.

Sympathetic activity may thus be inhibited, but it is sometimes possible to go a step further in the investigation and to produce a temporary paralysis of portions of the sympathetic system by means of local anæsthetic drugs. The vasoconstrictor fibres to the legs are readily paralysed by a spinal anæsthetic given so that the upper limit of the anæsthesia reaches the level of the umbilicus, and thermocouples attached at different levels on the extremity will indicate the condition of the peripheral as compared with the more proximal vessels, as well as the total increase in the blood-flow produced by loss of vasoconstrictor tone.

J. C. White[2] has elaborated a technique for paralysing the sympathetic supply to the brachial plexus by injecting local anæsthetic close to the posterior extremities of the first and second ribs so as to infiltrate the tissue between the pleura and the heads of the ribs through which the sympathetic trunk is passing, and he has used this method as a guide in selecting the cases of vascular disease in the upper extremity which are suitable for sympathectomy. Horner's syndrome is observed when the injection has been correctly performed.

OPERATIONS FOR GANGLIONECTOMY.

1. **Cervico-thoracic Ganglionectomy.**—The object of this operation is the removal of the inferior cervical and the first and second thoracic ganglia, and it is a matter of opinion whether this can be more readily achieved by an anterior or by a posterior approach. There is no doubt that the trunk lies nearer the back of the body, but the posterior operation advocated by Adson[3] traverses very vascular muscles and involves the removal of portions of one or, more commonly, two ribs on each side. The sympathetic trunk and its ganglia lie anterior to the thoracic nerves, and the upper part of the inferior cervical ganglion has to be drawn downwards from under cover of the first thoracic nerve, and the complete removal of this ganglion may present considerable difficulty to anyone not particularly familiar with the operation.

The anterior approach, as described by Professor Gask in the Bradshaw Lecture given at the Royal College of Surgeons in December, 1932, in spite of the greater depth of the thoracic trunk from the surface, is a procedure which involves less damage to the tissues, gives a perfect exposure, and, if the anatomy of the part be studied carefully beforehand, will be found to present no difficulty.

2. **Lumbar Ganglionectomy.**—When both lumbar trunks are to be excised the operation is commonly performed by the anterior transperitoneal approach described by Adson.[3] Excision of the lumbar trunk on one side only, and

excision of both sides in certain cases in which it may be inadvisable to open the peritoneal cavity, is most conveniently carried out through an incision in the loin, following Royle's technique.[4]

EFFECTS OF SYMPATHECTOMY.

1. Blood-vessels.—

a. Arteries.—It has been mentioned already that removal of the sympathetic produces arterial dilatation, and that the degree of dilatation may be determined by observing the rise in the temperature of the affected part. The accompanying chart (*Fig.* 1) records the temperature of the fingers of both hands after cervico-thoracic ganglionectomy on the right side. The temperature of the right side is constantly higher, and even after immersing the hands in water at 15° C. for thirty-five minutes the right hand could

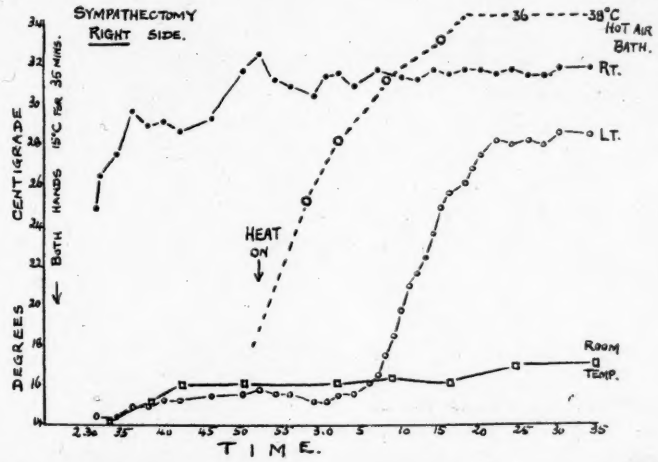

FIG. 1.—Response to heating the body in a patient with normal blood-vessels. Examination performed nine days after cervico-thoracic sympathectomy on right side. The left side shows the normal response. Time in minutes.

not be properly cooled, its temperature rising rapidly after removal of the hands from the cold bath, while the temperature of the left hand remained low and rose normally as the body was heated. The patient from whom these readings were taken was not suffering from any disease of his blood-vessels—the sympathectomy had been done to relieve pain—and he may be regarded as exemplifying the effect of sympathectomy upon normal arteries.

It was shown by Goltz and Freusberg as long ago as 1874 that in the course of time a moderate degree of tonus returns in vessels deprived of their vasoconstrictor nerves; and we have evidence that the results of their animal experiments hold good for man also. One of our patients had cervico-thoracic ganglionectomy performed for a form of arthritis affecting the right arm, the blood-vessels themselves being free from organic disease. Shortly after the operation the temperature of the right hand was considerably raised and the temperature of the hand rose immediately after a period of immersion in cold water. But when she was examined again six months later it

was noticed that the right hand was paler and cooler than the left, and it seemed to her that the temperature of this hand varied more with the external temperature than with the body temperature. After cooling both hands to 15° C. for twenty minutes the body was warmed up in the hot-air bath, and the chart shows that whereas the left hand responded normally to warming the body, the temperature of the right hand remained low, approximating to that of the rather cold room (*Fig.* 2).

It will be seen, therefore, that if after sympathectomy a considerable degree of tonus appears in the denervated vessels, the condition of the patient may be more precarious than it was before the operation, since the vessels are no longer under the control of the nervous mechanism. Lewis's investigations of patients after sympathectomy have led him to the conclusion that there are vasodilator fibres in the sympathetic, and the failure of a limb to warm up some months after operation may be due partly to blocking of vasodilator impulses.

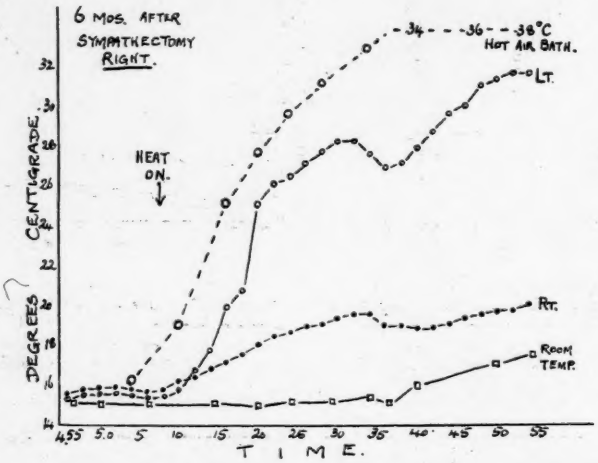

FIG. 2.—Response to heating the body in a patient with normal blood-vessels six months after cervico-thoracic sympathectomy on right side. Normal response on left side. Note more gradual rise of temperature in denervated fingers. Time in minutes.

Cold can produce vasoconstriction reflexly through the vasoconstrictor nerves, but it can also do so by acting directly upon the vessels themselves. The tonus acquired by denervated vessels may therefore be hastened in its onset and increased in intensity by cold. This is in accord with our clinical observations and is of great importance in connection with Raynaud's disease. It has been shown by Lewis that in this condition the fault lies in the small arteries, which are unduly susceptible to cold, and not in their nerve-supply. This conclusion is supported by the result of sympathectomy, for in all our patients who suffered from Raynaud's disease, though their hands were warm after operation, and their limbs showed all the signs of complete sympathetic denervation, coldness and cyanosis of the fingers could be produced by immersing the hands for twenty minutes in water at 15° C. This observation is well illustrated by comparing the chart of the finger temperatures of a patient with normal vessels and that of a patient with Raynaud's

disease, the readings before and after sympathectomy being superimposed (*Figs.* 3, 4). Prior to all the observations the fingers were cooled to 15° C. for not less than twenty minutes. Before sympathectomy the skin temperatures of both subjects rose as the body was heated, though the sufferer from Raynaud's disease showed a much delayed response. After sympathectomy it was impossible to cool the hand in which the vessels were normal; but in the case of Raynaud's disease the hand failed to warm up in spite of heating the patient's body, the skin temperature rising only very slowly with that of the surrounding atmosphere.

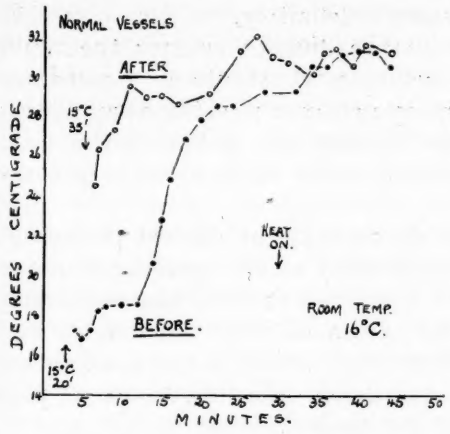

FIG. 3.—Composite chart from same finger of a patient with normal vessels before and after cervico-thoracic sympathectomy. After operation the effect of prolonged cooling of the hand passes off very rapidly.

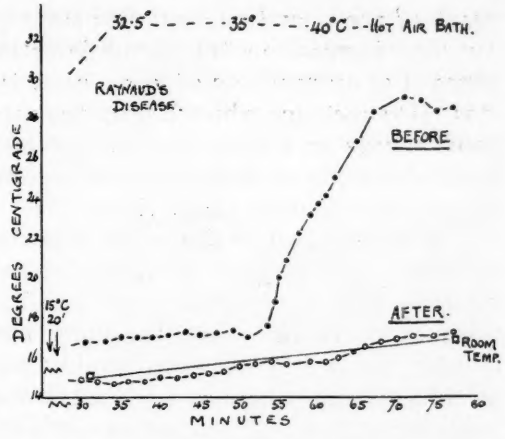

FIG. 4.—Composite chart from same finger of patient with Raynaud's disease before and after cervico-thoracic sympathectomy. Susceptibility of vessels to cold persists after complete sympathetic denervation.

When sympathectomy affords only moderate relief in Raynaud's disease it is sometimes assumed that the operation must have been incomplete. It must be clearly stated, however, that unsatisfactory results may follow complete sympathectomy; and further that the arteries not only retain their susceptibility to cold after sympathectomy, but that in time they may become less responsive to warming the body. It is fortunate that cases vary considerably in severity, and it is only the minority which do not derive considerable benefit from the operation, since under the usual conditions of exposure to a temperate atmosphere the extremities have a higher mean temperature than they had before the operation.

b. Arterioles and Capillaries.—Whereas the arteries are controlled by vasomotor nerves, the minute vessels (arterioles and capillaries), though supplied by nerve filaments, are controlled by chemical bodies, the most important of which is commonly referred to as 'H' substance, whose action upon the minute vessels is the same as that of acetylcholine and histamine. Any tissue injury gives rise to the local production of this 'H' substance, and Lewis[5] in 1927 brought forward experimental evidence to show that vasodilatation resulting from nervous impulses is due to liberation of 'H' substance at the nerve endings.

Though the minute vessels may be more accurately observed by capillaroscopy, a simple and reliable indicator of the state of these vessels is the colour of the skin. For the first forty-eight hours after cervico-thoracic ganglionectomy the face is flushed, the conjunctiva congested, the hand is hot and red, and the patients sometimes notice a bursting feeling in the extremity. Capillary pulsation in the fingers is frequently observed. But after this initial period has elapsed there is a gradual increase in the tone of the minute vessels, pulsation in them disappears, the conjunctival congestion is lost, and the skin of the denervated arm and hand becomes paler than that of its normal fellow. The limb thus becomes hotter but paler as a result of the operation, and this state persists indefinitely.

The increase in the blood-flow through the arteries ensures the rapid removal of all products of tissue activity, including 'H' substance; and since it is 'H' substance which dilates the minute vessels, the washing away of this body results in constriction of the minute vessels, and pallor of the skin. It is interesting to note here that certain observations we have made of cases of causalgia confirm these views.

Vasodilatation is the most important element in the clinical picture of causalgia—the peculiar burning pain which follows certain peripheral nerve injuries—and on theoretical grounds Lewis suggested that all the manifestations of nerve irritation, including the formation of herpetic vesicles and trophic changes in the skin, would find their explanation in the local action of 'H' substance liberated by antidromic impulses. The following case provides experimental evidence in support of the theory.

V. F., male, 23 years of age, a paper maker, lost the end of his right thumb in a machine accident in December, 1929. The stump healed in three weeks but remained tender, and amputation through the proximal phalanx was performed in March, 1930. Severe causalgia developed involving the distribution of the outer branch of the median nerve, and he was unable to work. In September, 1931, peri-arterial neurectomy of the right brachial artery gave partial and temporary relief, but six weeks later the condition was worse than ever, and there were recurrent crops of herpetic vesicles on the pad of the index finger (*Fig.* 5). In November, 1931, after the man had been unable to work for two years, cervico-thoracic ganglionectomy was performed on the right side. Within forty-eight hours the herpes had completely dried up, and as the red skin of the thenar eminence and index finger became pale, hyperæsthesia disappeared entirely. A tender spot remained in the amputation scar, which proved to be an end-bulb, and since it has been excised the hand has remained free from all pain and hyperæsthesia, and the man is back at work.

FIG. 5. — Distribution of vasodilatation and herpetic vesicles in causalgia of outer branch of median nerve. Vesicles disappeared, and vasodilatation of minute vessels was abolished after sympathectomy.

We can tell from his specimens and his writings how carefully John Hunter studied vasomotor phenomena, and he would have been interested to see the modern work which is gradually elucidating the mechanisms which control them. Hunter can have known nothing of the functions of the sympathetic system, for though the lateral trunks were accurately described and named by Winslow when Hunter was a child, the work of Claude Bernard,

which marks the beginning of our knowledge of the physiology of the sympathetic, appeared sixty years after Hunter's death.

In his *Lectures on Inflammation*, we read: "I propose to state a few of the facts which throw some light upon the vascular system by showing that there is in vessels a power of muscular action, and that the co-operation of elasticity is also necessary to their function"; and "The colour of an inflamed part is visibly changed from the natural hue, whatever it was, to red. This red is of various hues, according to the nature of the inflammation. The increase of red would appear to arise from two causes, first dilatation of the vessels and secondly the formation of new vessels." Surely John Hunter's enthusiasm for searching out the secrets of human physiology and pathology would be stirred if he were shown that redness of the skin can be produced by irritation of a sensory nerve, and that this skin can be blanched by sympathetic denervation.

2. **Secretion of Sweat.**—Though pilocarpine will induce sweating in an area completely deprived of its sympathetic nerve-supply, sweating which normally results from exercise or from heating the body is produced reflexly, and is always absent in an area whose sympathetic supply has been severed from the centres in the spinal cord. The line which separates the dry from the sweat-covered skin is an amazingly sharp one, and is quite a reliable method of determining the extent of the sympathetic denervation (*Fig.* 6). The test does not differentiate between areas denervated by section of postganglionic as distinct from preganglionic fibres, since the whole area of skin whose preganglionic supply has been cut will be dry.

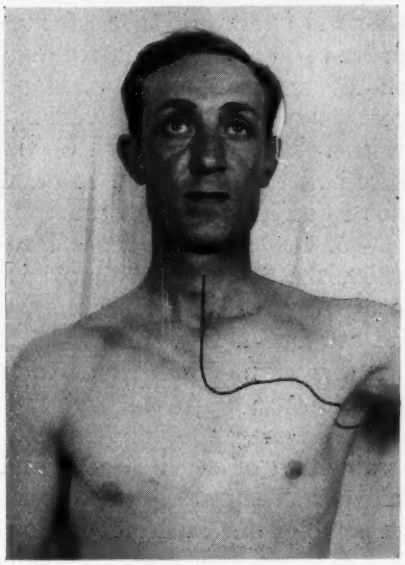

FIG. 6.—Left side of face and neck, left arm and shoulder, and the chest above and to the left of the line completely dry, rest of body bathed in sweat after exercise. Cervico-thoracic sympathectomy, left, by anterior approach.

Some of our patients have stated emphatically that the secretion of sweat has been considerably more profuse in the areas not affected by the operation. At first we were inclined to regard this merely as an error of observation, the usual amount of sweat being considered excessive when contrasted with the completely dry denervated area. However, the remark has been so frequently made, and it has been possible to observe the profuse secretion so often, that the possibility of compensatory hypersecretion cannot be excluded.

3. **Pilomotor Mechanism.**—Goose skin may be made to appear as a response to central or peripheral stimulation. If a block of ice is placed between the shoulder-blades, goose skin appears over a wide area as a result of a spinal reflex, and this response is lost after section of any of the sympathetic fibres to the part, whether preganglionic or postganglionic. After

sympathectomy the area over which this pilomotor response is absent corresponds to the area of skin which remains dry when the body is heated.

But goose skin may also be produced as a result of fairly powerful faradic stimulation of the skin. The response is obtained more readily in some subjects than in others, and we have not used the test extensively because many patients find it distinctly unpleasant or even acutely painful. The importance of the test is that electrical stimulation will produce goose skin even though the preganglionic fibres to the part have been severed; but it is not effective after section of postganglionic fibres when the period required for degeneration of the fibres has elapsed. The test is therefore of value in determining the exact distribution of postganglionic fibres from particular sympathetic ganglia.

4. **Muscular Power.**—Though we have no observations of muscle tone to record, we have noticed that a constant sequela of sympathectomy is weakness of the voluntary muscles in the affected limb. This loss of power may be shown by dynamometer readings, but it is quite obvious without this test, for the patients have been unable for some days after the cervico-thoracic operation to hold a cup while drinking, or to grasp an orange in order to peel it; and a feeling of weight in the arms, and of dragging at the shoulders owing to weakening of the shoulder-girdle muscles, is a common complaint which is relieved by massage and disappears completely in a few weeks. The explanation of this phenomenon is not clear, but it has been assumed that it is due to circulatory changes in the muscles, and certainly not to anything which causes permanent paresis.

5. **Oculomotor Phenomena.**—In a brief but brilliant paper published in 1869, the Swiss ophthalmologist, Friedrich Horner, described a case showing ptosis, myosis, enophthalmos, and diminution of intra-ocular tension which he attributed to paralysis of the cervical sympathetic. He also mentioned the dry warm skin of the face on the affected side, his accurate studies of skin temperature being the first to be made in a clinical case (Fulton).

The preganglionic fibres to the eye may be interrupted by lesions of the brain-stem or cervical cord and by injury to the lower part of the brachial plexus. They are always divided when the stellate ganglion is removed, but in some of our earlier operations in which we merely divided the sympathetic trunk below the stellate ganglion the eye fibres escaped injury, thus showing that they pass out from the cord in the white ramus from the first thoracic segment.

For the first few days after cervico-thoracic ganglionectomy ptosis is very marked, the conjunctival vessels are engorged, and the tension in the eyeball falls to such an extent that accommodation may be impaired. It has occasionally been necessary for patients who have previously worn glasses to have their lenses altered subsequently.

Later the ptosis becomes less marked and the intra-ocular tension rises somewhat, but in none of our patients has restoration of function been complete, even after the lapse of two years, though no appreciable disability results. It is stated that in lower animals complete recovery of the eye eventually occurs, and this difference between man and the lower animals may be of importance, since it would appear that in man the intact excitor

cells and postganglionic fibres cannot function perfectly when the preganglionic portion of the system has been destroyed. It seems probable that this rule may apply to other parts of the sympathetic system in man.

6. Visceral Motor Mechanism.—

a. Colon.—Twenty years ago intestinal stasis was explained by the leaders of surgical opinion on mechanical grounds. The intestine was regarded as a tube subject to obstruction by kinking, with subsequent atony of the portion proximal to the kink. Keith published a paper in 1915 combating this mechanical view and suggesting that symptoms resulted not from atony, but from hypertonicity of those parts which are normally in a state of tonic contraction, thus postulating a disturbance of the neuromuscular mechanism to replace the mechanical theory of intestinal stasis. Keith's conception followed naturally upon the work of Bayliss and Starling on peristalsis, and upon Elliott's investigations into the nerve-supply of the sphincters which Keith himself had described.

FIG. 7.—Megacolon. Barium enema—seven pints given without discomfort.

We may deduce from experimental data that in the normal individual the antagonistic activities of the sympathetic system and of the cranial and sacral autonomics are in a state of equilibrium. But if the balance is upset so as to produce a preponderance of sympathetic activity in any portion of the alimentary tract, the result will be inhibition of the viscus and increased tonus of its sphincter, with consequent stasis of its content. In spite of Keith's plea to regard the colon as a neuromuscular organ rather than as a sewage pipe, nearly fifteen years had to elapse before surgeons began to apply his ideas to practice. Even then the notion of operating upon the sympathetic system to influence bowel movement seems to have originated in an almost accidental, or at least incidental, observation by Royle, who noted that when he operated on the lumbar trunks for spastic conditions of the legs, certain of his patients who had previously suffered from chronic constipation were relieved of this condition.

In attempting to assess the activity of the sympathetic supply to the bowel, the history of the case and the general condition of the patient may be very helpful. But the most accurate information we are able to obtain at present comes from the careful study of a barium enema, correlated with the patient's sensations, and the effect of spinal anæsthesia upon the barium-filled colon (Scott and Morton[6]).

The remarkable feature as regards the patient's sensations is that pint after pint of barium emulsion can be administered without any complaint of fullness or distension. Seven pints were run into the bowel before the X-ray

picture shown in *Fig.* 7 was taken, yet the patient, who was only 14 years of age, suffered no discomfort. A spinal anæsthetic was then given so as to produce anæsthesia to the level of the umbilicus. Shortly afterwards the patient complained of what seemed to be a colicky pain, and a wave of peristalsis was seen to pass along the colon, a large quantity of the barium being expelled from the rectum (*Fig.* 8).

It might be expected that the spinal anæsthetic would paralyse all the nerves passing to the bowel, yet the increase in its activity must be taken to show that the predominant effect of the anæsthetic is to cut off the sympathetic inhibition, leaving the intrinsic mechanism of the bowel to act unimpeded.

The sympathetic nerve-supply to the left side of the colon may be interrupted by the operation described by Learmonth and Rankin,[7] and the effect of this sympathectomy is indicated by the frequency of bowel actions, by the patient's subjective sensations, and by changes in the X-ray findings. The bowels, instead of being opened once a week, will act daily; and whereas large doses of purgative drugs were previously ineffective, a mild aperient will prove sufficient to correct any tendency to constipation.

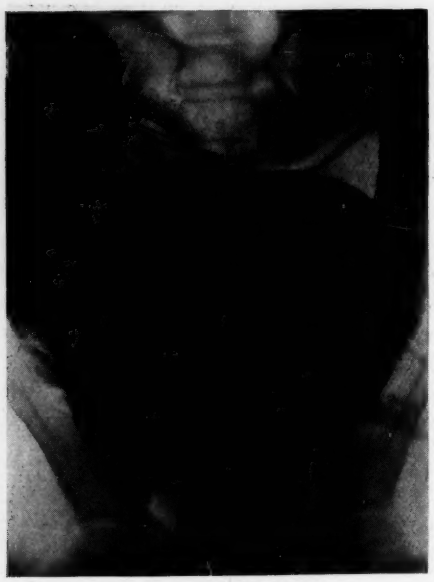

FIG. 8.—Megacolon. Barium enema after spinal anæsthesia. Picture taken a few minutes after *Fig.* 7. Peristaltic wave passing down descending colon has reached sigmoid colon. Barium was being expelled from rectum.

The patient who had previously lost, or had never experienced, the sensation of fullness in the lower bowel which promotes the act of defæcation, will subsequently acquire such tonus in the bowel that distension with fæces will give rise to the normal sensation; an enema will also produce this feeling of fullness, leading to evacuation of the bowel contents.

Comparison of skiagrams of barium meals and enemata before and after operation will show that the meal is passed on more rapidly from one section of the intestine to the next; and, instead of the greatly distended colon with a smooth wall, a more contracted gut with many haustrations will be outlined.

b. Bladder.—The nervous control of the bladder musculature involves the balanced activity of the sacral autonomic and sympathetic nerve-supply. The pelvic nerves (sacral autonomics) contain afferent as well as efferent fibres, the efferents being motor to the detrusor muscle and inhibitory to the internal sphincter, this supply being essential to micturition. The sympathetic impulses travel in the hypogastric (presacral) nerves whose efferents are inhibitory to the detrusor muscle and motor to the internal sphincter.

Learmonth[8] has had the opportunity of stimulating the presacral nerve in patients under spinal anæsthesia, while at the same time the bladder was observed through a cystoscope. He records that stimulation of the presacral nerve causes contraction of the ureteric orifices, increased tonus of the trigone, and contraction of the internal sphincter, the opposite effects being produced by section of the nerve. He also brought forward evidence that stimulation of the sympathetic by adrenalin causes a fall in intravesical pressure.

It must be remarked in this connection that a patient whose presacral nerve has been removed is likely to have transitory increased frequency of micturition, which may be explained by supposing that the desire to micturate, which is due to tension on the muscle of the viscus, can be produced by a smaller volume of urine than was necessary to give rise to this sensation before the nerve was excised.

Although the sympathetic fibres reaching the bladder through the presacral nerve are motor to the internal sphincter, even in the female incontinence of urine does not occur after section of this nerve. Since micturition can be carried out naturally after ablation of the presacral nerve it is clear that only the sacral supply to the bladder is essential, though any disturbance of the balance with preponderance of its sympathetic antagonist may produce symptoms.

The most prominent symptom is an absence of the normal desire to micturate, and in one of our patients who neglected to empty her bladder at regular intervals attacks of retention of urine supervened. After the presacral nerve had been excised the desire to micturate at regular intervals returned, the stimulus being the accumulation of a certain volume of urine in the bladder. If it is allowed that the sympathetic induces relaxation of the detrusor muscle, acting as a brake on this muscle and so preventing a rise of pressure within the bladder as urine collects in it, then the return of the sensation of fullness after interruption of the sympathetic supply will be readily understood.

7. Sensation.—

a. Visceral Sensation.—

i. *Pelvic Viscera.*—Learmonth, in the course of his investigations under spinal anæsthesia, found that though there was analgesia below the tenth thoracic segment, manipulation of the presacral nerve was painful and the pain was referred to the bladder region.

Excision of the presacral nerve has been practised for the relief of pain in carcinoma of the bladder with varying degrees of success, but it is uncertain whether the relief afforded is due to interruption of an afferent path or to relaxation of spasm of the bladder neck. Certain types of uterine pain also have been relieved by the excision of the presacral nerve, but here again the important factor may be interference with efferent rather than with afferent fibres.

ii. *Cardiac Pain.*—The sympathetic nerves mediating cardiac pain are said to be derived from the middle and inferior cervical ganglia ; and afferent impulses would pass by them to these ganglia and enter the spinal cord by the white rami communicantes of at least the first three and possibly the first five thoracic nerves, thus accounting for the distribution of the referred pain of

angina pectoris (*Fig.* 9). Leriche claims to have stopped an attack of angina, which occurred while he was actually operating, by injecting novocain into the inferior cervical ganglion.

If this is the path followed by pain which has its origin in the heart, the most rational procedure for its relief is removal of the inferior cervical and first and second dorsal ganglia. In order to avoid the risks of this operation in such patients, White[9] has advocated blocking the rami of the upper five thoracic nerves on the left side with alcohol, making the injections from the back. I have had the opportunity, with Dr. Geoffrey Bourne, of treating one patient by this method with benefit. According to Cutler's figures operation which includes removal of the inferior cervical and first thoracic ganglia will relieve the pain in about 70 per cent of cases of angina pectoris.

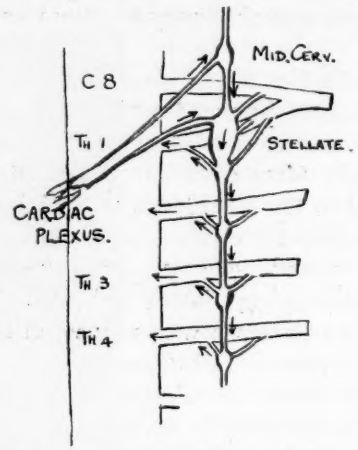

FIG. 9.—Diagram to indicate the path of the pain impulses in angina pectoris.

b. PERIPHERAL SENSATION.—A great deal of confusion in regard to the afferent function of the sympathetic has arisen from the fact that causalgia, though it may persist after various attempts to treat the injured nerve itself, is frequently relieved by sympathectomy. This has led certain clinicians, especially in France, to suppose that causalgia is a neuritis of sympathetic fibres and that the pain in causalgia is conveyed by sympathetic afferents.

It now seems clear, however, that causalgia arises from stimulation of sensory nerve-fibres along which antidromic impulses pass to the area of skin supplied by the nerve, these impulses leading to the local liberation of chemical bodies ('H' substance) which produce vasodilatation and the other trophic changes which characterize the condition. The area of irradiated pain and hyperæsthesia in causalgia is always the site of well-marked vasomotor disturbance, and relief of the symptoms occurs only as a result of treatment directed to the abolition of this vasomotor disturbance. It has already been mentioned that sympathectomy produces such an increase in the blood-flow through the small arteries that the 'H' substance which is responsible for dilatation of the minute vessels is washed away and these vessels become constricted. This constriction of the minute vessels is associated with relief of causalgia, and in this change lies the secret of the success of sympathectomy.

There is evidence to suggest that the characteristic pain may originate in the blood-vessels themselves, but we have been unable to discover anything in our own clinical material to show that the sensation is conveyed along sympathetic pathways. Blood-vessels, especially towards the distal portions of the limbs, are well supplied with nerves, but, as far as we can determine, sympathectomy has no effect upon the pain of arterial puncture. With the help of Dr. Carmichael all forms of sensation were tested in a small group of patients upon whom unilateral cervico-thoracic ganglionectomy had been performed a few months previously, and there was no appreciable difference in the sensation of the two sides. From our own experience, therefore, we must conclude that as sympathectomy is not followed by any impairment of sensation in the limbs, it is unlikely that afferent impulses travel from the limbs to the central nervous system along sympathetic nerves.

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A CASE OF PARATHYROID TUMOUR.

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THE condition of hyperparathyroidism, since it was recognized and first treated surgically in 1926, has become almost a common disease. Upwards of fifty examples have been treated by operation and described in the journals of Europe and America, so that it might appear superfluous to describe yet another in this JOURNAL, and the more so because a very full account of the disease was published in its pages by Donald Hunter[1] and A. J. Walton[2] so recently as October, 1931. In reading the published accounts of the disease, it has appeared to me that attention has perhaps been focused too much upon the changes in the skeleton and too little upon the condition of the patient as a whole, and it may therefore be worth while to publish a fuller account of a single patient than is usually given, since this patient presents so very complete a picture of the disease, a picture which includes practically every feature that has ever been recorded in hyperparathyroidism, with the addition of one or two that are unusual.

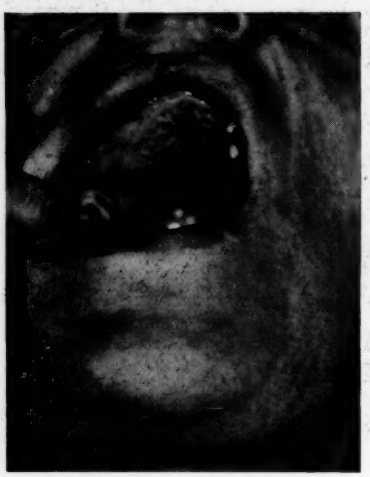
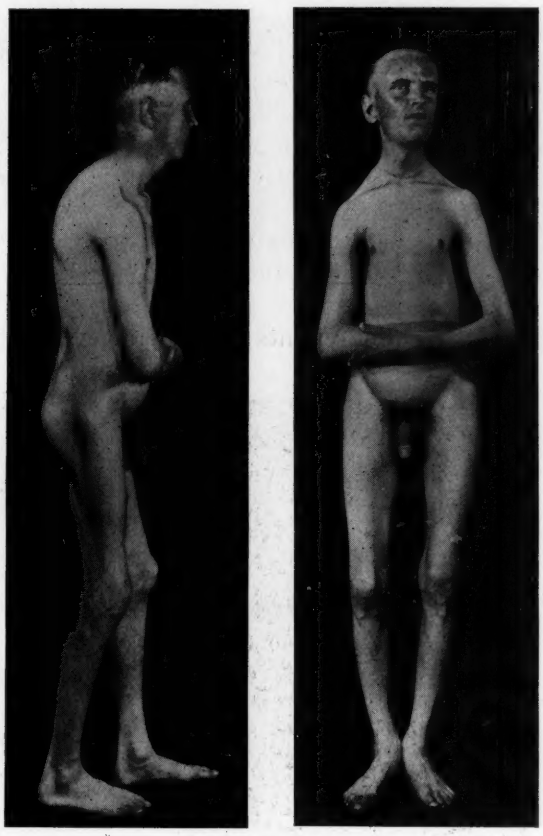


FIG. 10.—Showing widening of right upper alveolar margin.

The patient, a male, first became ill at the age of 18 in January, 1925, when he was admitted to the medical wards at St. Bartholomew's Hospital. The initial symptoms were *acute abdominal pain* with *persistent vomiting*, and there was *considerable wasting*. At the same time there were urinary symptoms, with *frequency of micturition*. Renal tuberculosis was suspected, but the urine appeared to be normal, and eventually a small *calculus* was passed by the urethra. A few months later (May, 1925) it was realized that the frequency of micturition was due to *polyuria*. At the same time the gastric symptoms continued, and a gastric ulcer was tentatively diagnosed. Proof of this, however, was lacking, and the diagnosis gave way to suspicions of anorexia nervosa or Addison's disease.

The symptoms abated with gastric lavage, and the patient remained fairly well until August, 1926, when there was recurrence of the vomiting, and a second small calculus was passed by the urethra. A slight *albuminuria* discovered at the same time led to a suspicion of chronic nephritis. He was

found to have some degree of *gastroptosis* and *atony of the stomach*, but no further light was obtained as to the diagnosis. In November, 1926, the patient first complained of *pain in the right knee-joint*, with stiffness. The other symptoms were more or less in abeyance, with occasional recrudescence of the vomiting, until May, 1928, when he first came under my own observation with a diffuse bony swelling of the right upper alveolar margin (*Fig.* 10). Many of the pecularities in the conformation of his skeleton (to be presently described) were then noticed, but their real significance was not appreciated. The swelling in the right maxilla was explored, and a diffuse new growth was diagnosed, the histology being that of a typical *osteoclastoma*, with large numbers of multinucleated giant cells.



FIGS. 11, 12.—Showing skeletal deformity and muscular atony.

The patient developed no new features for some time, and was next admitted to hospital with a diffuse swelling of the lower jaw in February, 1930. His general condition appeared then to be unchanged, and exploration of the mandible again produced evidence of new growth resembling osteoclastoma. The maxilla did not appear to have altered, and consequently no further treatment was undertaken.

In July, 1931, the patient began to complain of new symptoms — namely, *aching in the bones* of the limbs, particularly in the right humerus, and troublesome *headaches*. These persisted until the end of that year, when he was more ill in every way. He complained of increased *wasting*, of *dyspnœa*, and of severe *lassitude*. Finally, in January, 1932, he suffered a *spontaneous fracture* of the right humerus. By this date a number of parathyroid tumours had been observed and described, so that the diagnosis was no longer in doubt. The patient remained for some time in a cottage hospital, and was not re-admitted to St. Bartholomew's Hospital until June, 1932, by which time the fracture of the right humerus had firmly united, with slight angulation about the middle of the shaft.

At this date the general appearance of the patient was as seen in the photographs (*Figs.* 11, 12) taken two months later, though he was rather more wasted, and there was a more pronounced degree of *muscular atony*.

These pictures show the features summarized below, and it was seen in addition that he had brilliantly *blue sclerotics.*

Head and Face.—Forehead high, broad, and square; the whole head is large in proportion to the body. The right malar region is prominent, corresponding to the enlargement of the maxilla already mentioned; the lower jaw is rounded and thickened.

Thorax.—The chest is narrow and cylindrical, and tapers upwards from the waist. The dorsal spine shows kyphosis and scoliosis. There are numerous bony swellings on the ribs.

Abdomen and Pelvis.—The abdomen is prominent and lax, and the pelvis is wide, with prominent iliac crests.

Lower Limbs.—The great trochanters are prominent and raised. All the signs of bilateral coxa vara are present. There is genu varum, the femurs and tibiæ being thickened and curved. There is an enlargement of the upper end of the left fibula. The right knee cannot be fully extended.

Feet.—Tendency to flat feet, but otherwise normal.

Upper Limbs.—Right humerus angulated about its middle. Swellings in the upper parts of the right ulna and the left radius.

Hands.—The appearance of the hands is very peculiar, and the condition does not seem to have been previously described. The chief abnormality is in the terminal joints of the fingers (*Fig.* 13). These are very short and

FIG. 13.—Showing abnormality of terminal phalanges and nails.

square, and the nails are correspondingly broad and short. The finger-ends are slightly bulbous, but do not resemble the 'clubbing' of pulmonary osteo-arthropathy.

The X-ray examination showed generalized osteitis fibrocystica, with other features corresponding to the deformities mentioned above. Most of these were of the usual type, and do not demand detailed description. The following points, however, are worthy of attention.

Skull (*Figs.* 14, 15).—This shows very well the thickening of the vault with fluffiness of the bone, and the clear area in the right maxilla corresponding to the tumour previously explored.

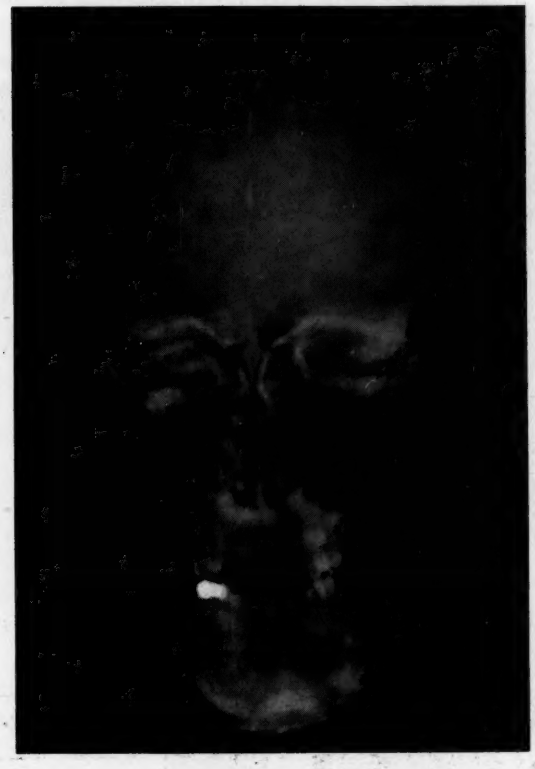


FIG. 14.

FIG. 15.

FIGS. 14, 15.—Skiagrams showing thickening of vault of skull, with fluffiness of bone. The clear area in the right maxilla (*Fig.* 14) corresponds to the tumour previously explored.

Humeri (*Figs.* 16, 17).—This series of radiograms shows the extreme degree of cystic degeneration in the right humerus with the first fracture united, and with a second spontaneous fracture which was sustained after the removal of the parathyroid tumour. The left humerus, however, shows

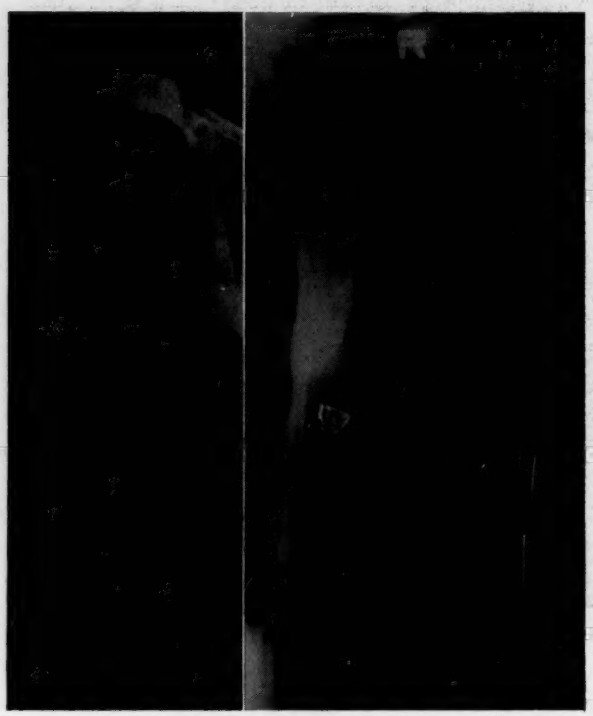


FIG. 16.

FIG. 16.—Radiogram of humeri, showing cystic degeneration in the right and general fluffiness and osteoporosis in the left.

FIG. 17.

FIG. 17.—Radiogram of right humerus, showing first fracture united and second spontaneous fracture sustained after the removal of the parathyroid tumour.

no cysts, but a general fluffiness and osteoporosis resembling that seen in the cranium.

Hands (*Fig.* 18).—There is a conspicuous shortening of the terminal phalanges corresponding to the outward abnormality already described.

Right Knee-joint (*Fig.* 19).—This shows a remarkable degree of metastatic calcification involving the whole of the synovial membrane and the insertion of the quadriceps femoris into the patella. This change was presumably heralded by the onset of pain and stiffness in the joint in November, 1926. The left knee does not show any corresponding change.

The general muscular atony was a conspicuous feature of the patient's condition in 1932. It has been claimed in a recent paper by Max Ballus[3]

that the presence of atony is a more important diagnostic feature even than a high serum-calcium figure, and he has devised methods for accurately

FIG. 18.—Skiagram showing marked shortening of terminal phalanges (with control on right).

measuring its degree. The associated biochemistry of the patient described here was fully investigated by Mr. Hermon Taylor, who gives details in an appendix to this article. The increase in the serum calcium was held to clinch the diagnosis, though no definite tumour could be detected on either side of the neck.

FIG. 19.—Skiagram of right knee-joint showing metastatic calcification involving the whole of the synovial membrane and the insertion of the quadriceps femoris into the patella.

In July, 1932, the neck was explored through the ordinary collar incision. Nothing abnormal was found on the right side. On the left side a cystic tumour was found below and behind the lower pole of the thyroid gland, and was easily removed. This measured 3·5 × 2·5 cm., and was therefore larger than most of the recorded examples. The greater

part of it, however, was cystic, and the amount of secreting tissue it contained was not great. Its histological structure conformed to those already described in this JOURNAL.

The serum-calcium figure fell abruptly after the operation (*see* Appendix), and at the same time the patient's symptoms rapidly abated. His headache disappeared, and he soon expressed himself as feeling better than he had done for years. The premonitory signs of tetany were present for a few days in the form of tingling in the fingers, toes, and nose, but there was no further development. Four months later he was feeling vigorous and active, and the right humerus, originally the most profoundly altered bone in his body, was plainly undergoing re-calcification.

APPENDIX.

By HERMON TAYLOR.

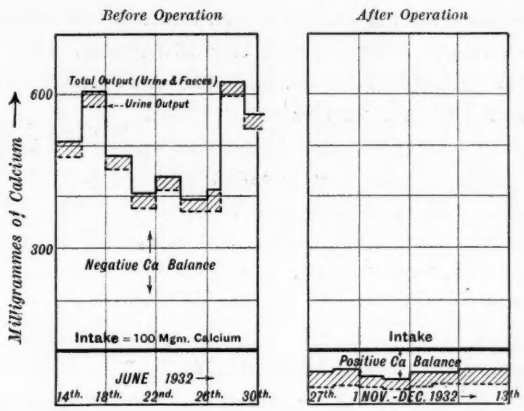
The diagnosis of hyperparathyroidism depends largely on two factors: (1) The X-ray appearances of the bones; and (2) An excessive loss of calcium from the body *by way of the urine.* In the blood a high value of calcium and a low value of phosphorus *usually* accompany this mobilization of calcium from the bones. The level of the calcium in the blood is, however, only a rough indication of the total amount lost from the body, and for this reason, in the early series of cases of osteitis fibrosa, an investigation of the balance between calcium output and intake has been necessary in addition to an estimation of the level of calcium in the serum.

In the cases which have been studied so far, which have appeared clinically and radiologically to be osteitis fibrosa, and in which the serum calcium has been high, an excessive loss of calcium has been found. It appears therefore that, for the routine case of the future, clinical signs of osteitis fibrosa together with a high serum calcium will be sufficient to establish a diagnosis. It must be borne in mind, however, that a normal serum calcium does not negative the diagnosis unless associated with normal calcium output in the urine. It is only in rare cases, which, in spite of a normal serum calcium, still appear clinically to have osteitis fibrosa, that the prolonged and exacting investigation of the calcium balance is necessary, as it is possible for a negative calcium balance to occur with a normal serum calcium.

In the patient here described, calcium and phosphorus balance experiments were performed, and the results are expressed on the four charts (*Figs.* 20, 21). The calcium and phosphorus intake was determined by keeping the patient on a fixed diet of sufficient caloric value with the low calcium content of 100 mgrm. per day, giving him only distilled water to drink. Forty-eight-hourly specimens of urine and four-day specimens of the stools were collected, the periods for the stools being marked off by doses of carmine by the mouth. Estimations of the total calcium and phosphorus in each of these were made and the results plotted on the graphs reproduced (*Figs.* 20, 21).

It will be seen that before operation there was a loss of calcium from the body amounting to roughly 350 mgrm. a day, whereas after removal of the parathyroid tumour there was a gain of calcium of 40 mgrm. a day, indicating that calcification was again taking place in the bones.

The phosphorus balance, on the other hand, showed very little abnormality in the direction of gain or loss before the operation; this is unusual, there being commonly a loss of phosphorus also from the body. The figures for phosphorus balance are, however, much more variable than those for calcium and are of less diagnostic importance than the calcium figures. After operation there was a slight gain of phosphorus.



Dotted line = output in urine. Shaded area = output in fæces.

FIG. 20.—Charts of calcium balance.

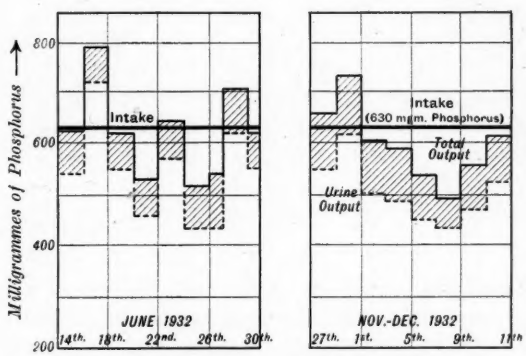


FIG. 21.—Charts of phosphorus balance.

It will be observed from the charts that the increased loss of calcium before operation occurred almost entirely by way of the urine, the amount excreted in the fæces differing very little from that after operation. This is characteristic of hyperparathyroidism, where the calcium mobilized from the bones seems to be excreted almost exclusively in the urine.

In this patient the combination of the X-ray appearances in the bones and the loss of calcium from the body by way of the urine determined the diagnosis of hyperparathyroidism, and it is interesting to note that this relatively large tumour was *not palpable* in the thin neck of the patient. The lower lobe of the thyroid on the opposite side of the neck was abnormally prominent on account of the cervical scoliosis, and this swelling was thought

before operation to be the tumour. The parathyroid adenoma actually lay on the other side of the neck behind the clavicle and sternomastoid.

From this experience it follows that inability to feel the tumour in the neck of a patient showing the clinical appearances of osteitis fibrosa and having a high serum calcium should not prevent one from exploring the neck.

The serum calcium in this case was 14·7 mgrm. per 100 c.c. before operation. Immediately after the operation the value fell to 8·4 mgrm. per 100 c.c., and remained at this level for more than three weeks. It was during this time that the patient experienced the numbness and tinglings of mild tetany. The plasma phosphorus, which was 1·47 mgrm. before operation, rose to 2·6 mgrm. per 100 c.c. at the same time.

Five months after the operation the serum calcium was 11·2 mgrm. per 100 c.c. (high normal), while the plasma phosphorus was 4·4 mgrm. per 100 c.c. (high normal). It is interesting to note that the plasmaphosphatase, which before operation was 0·31 units per c.c., fell to 0·09 units per c.c. (normal) five months after operation.

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POST-TRAUMATIC EPIDERMOID CYSTS OF HANDS AND FINGERS.

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Cysts lined, in part, by squamous epithelium occurring on the palmar aspect of the palm (*Fig.* 22) and fingers, and more rarely on the soles of the feet (*Fig.* 23) and on the scalp and face, have been recognized as a clinical entity for over half a century. Although they occur commonly, they exhibit features which are not generally appreciated. They are frequently

Fig. 22.—Drawing of the hand showing an epidermoid cyst of the hypothenar eminence.

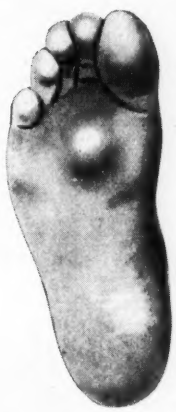

Fig. 23.—Drawing of a foot showing a typical epidermoid cyst.

termed 'implantation cysts' or 'implantation dermoids', a terminology which, in the majority of cases, has but little evidence for its support.

These cysts present problems of special clinical, pathological, and industrial interest and importance. The results of a study of twenty examples of cysts of the hand and fingers together with a brief review of the literature is here given. Their general features may be best exemplified by some typical cases.

CASE HISTORIES.

I. NO HISTORY OF INJURY BUT A BREAK IN THE SKIN.

Case 1.—A male, aged 49, engaged in active work on the permanent way of the railways, sought attention for a swelling in the palm of the left hand. Thirty-five years before this, in the region of the swelling, he had had a 'poisoned' hand, which had burst. After healing, a small 'lump' had remained and continued without any marked variation in size until, three months before seeking attention, it commenced to swell rapidly.

On examination there was seen an irregularly smooth, soft swelling, about 2½ in. in diameter, occupying the region between the base of the ring and little fingers and the proximal crease of the palm (*Fig.* 24).

The cyst was removed under local anæsthesia without difficulty. It was more extensive than the examination suggested and was lobulated, conforming with restrictions imposed on it by the surrounding structures (*Fig.* 25).

FIG. 24.—*Case* 1. Drawing of the left hand. The cyst was lobulated and fluctuant. (*See Fig.* 25.)

It was found to contain a curious fatty substance which differed from sebaceous material, however, in being less greasy, more gritty, and showing a crystalline sheen. On section of the cyst (*Fig.* 26) the contents were found to separate easily from the wall except at one place, where the material was harder, laminated, and closely adherent to the wall. This material was thought to be keratin, and subsequently proved to be so.

Microscopic examination of the wall showed that it was lined in part of its extent by a squamous epithelium without papillæ, and throughout the remainder by connective tissue containing spaces originally occupied by fatty material or cholesterol, around which there were giant cells of the foreign-body type. Phagocytic cells and numerous endothelioid cells, fibroblasts, small round cells with occasional polymorphonuclear leucocytes were also present. The cyst contents were mainly typical cholesterol crystals in one part and keratin in the other. In frozen sections small amounts of fat and fatty acid were demonstrated by their staining reactions to Nile blue, Sudan III, and neutral red. A minute quantity of double-refracting material, which also stained red with Nile blue, was present.

FIG. 25.—*Case* 1. Photograph of the specimen removed. The irregularly elongate portion projected, in the palm, towards the wrist and was not obviously palpable before operation. (× ¾.) (*See Fig.* 26.)

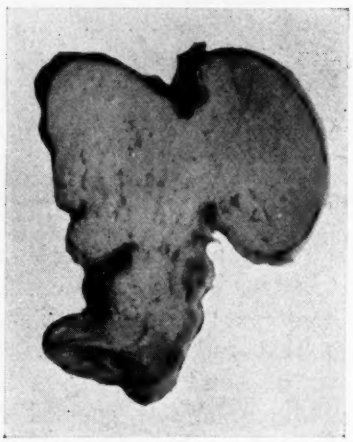

FIG. 26.—*Case* 1. Photograph of the cyst shown in *Fig.* 25 after section. It was filled with material resembling sebaceous matter except that it was more gritty and crystalline and less fatty.

Chemical investigation of the cyst contents showed that about half the contents was fatty material and the other half protein. Of the former, 98 per cent was cholesterol, nearly 2 per cent was fat, and the small remainder was fatty acid.

Bacteriological investigation revealed no organisms in the cyst or its contents. Examination of part of the cyst contents by the antiformin method for tubercle bacilli was negative.

II. NO HISTORY OF INJURY.

Case 2.—A male, aged 46, a rat-catcher, was treated for a swelling on the palm of the right hand. He had had this for six years; it was not painful, it had not been tender at any time, and there had been no marked increase in size. He could recollect no special injury to the hand. A rounded swelling about 1 in. in diameter was removed from the region of the base of the ring finger. The cyst was similar to that described in *Case* 1, except that its contour was ovoid.

Case 3.—A male, aged 35, by occupation a pile-driver, sought treatment for a swelling on the palmar aspect of the base of the little finger which he had noticed for eight weeks and which had been becoming larger during that time. There had been no special injury, though he had often bruised his hands. He could remember no injury with any breaking of the skin in this region. A typical cyst ¾ in. in diameter was removed.

III. INJURY BUT NO BREAK IN SKIN.

Case 4.—A male, aged 54, who had been attending a medical out-patient department for treatment for paresis of a lower limb which was due to a spinal-cord lesion. He had two swellings, one in the distal part of the first finger, and the other in the proximal part of the ring finger (*Fig.* 27). These caused some inconvenience when using his stick.

The swellings were oval and soft, and appeared to be attached diffusely to the skin. They were not attached to the deeper structures. The patient had noticed the swelling on the first finger since running a thorn into it several months before the time of the examination. As for the other, he was a boot maker by trade and used to run the laces through his fingers always in the same place. The cyst developed at this site. There had never been a wound at this spot. The cyst had been present for nearly a year. Both cysts were found to be typical epidermoid cysts (*Fig.* 28).

FIG. 27.—*Case* 4. Drawing of the hand showing two cysts. The cyst in the terminal portion of the first finger developed after a perforating injury, and that in the proximal portion of the ring finger after non-perforating trauma. (*See Fig.* 28.)

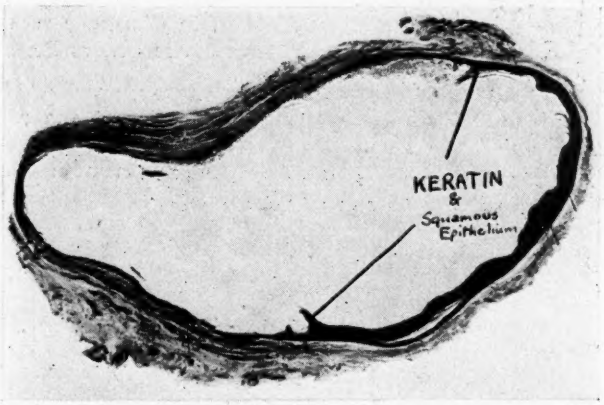

FIG. 28.—*Case* 4. Low-power photomicrograph of the cyst taken from the proximal part of the ring finger (*see Fig.* 27). It is lined in part of its extent by squamous epithelium (without papillæ) which is forming keratin (*see Figs.* 29, 30). The remainder is lined by connective tissue containing cholesterol and fat crystals and numerous giant cells. (*See Figs.* 29, 32). (× 7.)

Case 5.—A youth, aged 18, while fielding at cricket was struck over the head of the first metacarpal by a fast-travelling ball. There was immediate pain and swelling. A few days later the swelling measured about ¾ in. across and was tender on pressure. This remained, and six weeks later a cyst was removed. It contained old blood, in which there were some cholesterol crystals. The wall was fibrous and there were numerous phagocytic cells and giant cells in the wall. No definite epithelial cells could be found. This cyst was considered to be an early stage of the typical traumatic epidermoid cyst.

FIG. 29.—Photomicrograph of portion of the wall of the cyst (*see Fig.* 28) showing the junction of the stratified epithelium and the connective tissue lining. (× 50.)

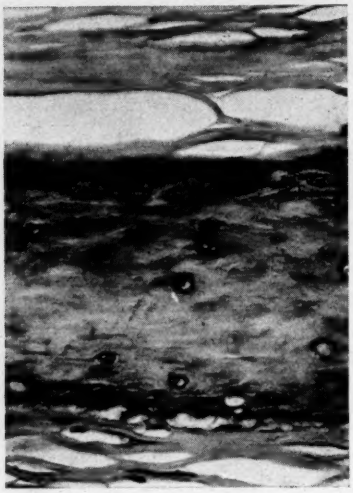

FIG. 30.—High-power photomicrograph showing the character of the squamous epithelium; there are no papillæ, a well-developed stratum granulosum, and a large amount of keratin. (× 410.)

Case 6.—A labourer, aged 32, while breaking stones jarred his hand with the handle of his hammer. This remained tender for some time, and within a few days he felt a 'hardness' in the region. He noticed no alteration until ten months later a 'lump' appeared at the site of the injury. This increased in size until eleven weeks later a cyst 1½ in. in diameter was removed. This cyst was similar to the others described.

FIG. 31.—*Case* 7. Drawing of the cyst of the hand.

Case 7.—A gardener, aged 42, bruised his hand at the base of the middle finger while shovelling earth. He noticed a small nodule after a few days, but this gave him no trouble and he continued work. Eight months later he noticed that this 'lump' was increasing in size, and nine weeks after observing the increase he sought attention. A rounded cystic swelling about ¾ in. to 1 in. in diameter was found (*Fig.* 31). This was removed, and proved to be a typical epithelium-lined cyst.

IV. INJURY WITH BREAK IN SKIN.

Case 8.—A labourer, aged 38, had his right hand caught between two heavy packing cases. The skin was burst in the palm for ½ in. and there was considerable bruising of the tissues. The wound healed without trouble, but a small lump remained under the scar. Seven months later this nodule began to enlarge, and continued to do so until it was over 1 in. in diameter. It was found to be a cyst similar to those already described.

V. INJURY WITH PERFORATION OF SKIN.

Case 9.—A wharf-labourer, aged 28, received a wound from a sharp hook. The wound healed without complication and he continued work. Five months later a swelling appeared in the subcutaneous tissues at a short distance from the scar. This gradually became larger until it was 1¼ in. in diameter. The cyst was similar to those already described.

HISTORICAL.

Epithelial cysts lined by squamous epithelium were first described by Rizet[46] in 1866. He applied the term 'dermoid cyst', and this view of the nature of the cysts was supported by several observers.[3, 18, 20, 32, 42, 49] This term may still be found in the literature.[23] Even modern text-books sponsor this view, and state (though not specifically referring to the hand) that such cysts are congenital in origin.

Following Rizet's description, a number of cases were described, and it was noted that the epithelium was not true skin in that it did not possess papillæ, and in 1881 Troquart gave to these cysts the name 'kystes épidermiques'. The contents of the cysts were observed to be like those of sebaceous cysts. Several specimens of cysts of this type were shown before the London Pathological Society, and two of these were called 'sebaceous cysts' by Bowlby[8] and Poland.[43] Villar [52, 53] and Darier[13] used the term 'kyste épidermique à contenu sebacée'. This terminology was followed by many writers, and indeed may still be encountered.[22] It was found, however, that sebaceous glands are not present in the palm of the hands, and Küster,[27] in order to support the sebaceous-cyst hypothesis, postulated that they must occur at times; but extensive investigations have shown them to be invariably absent.

Many of the preceding writers had observed that the development of these cysts was associated with injury, and indeed suggested that epithelium had been carried into the subjacent tissues. The relationship, however, was now emphasized by the use of such terms as 'kystes épidermiques traumatiques',[25] 'kyste épidermique consecutif à la traumatisme',[29, 30] 'traumatic epithelial cyst',[24] and 'traumatische Epithelcysten'.[17] It will be seen that the recognition of the importance of trauma was becoming general.

In an interesting paper embodying the investigation of three cases, Péraire[40] in 1892 reviewed the literature and emphasized both the relationship of the cystic development to trauma and also the difference of the cyst content from sebaceous material, and suggested the term 'kyste épidermique traumatique à contenu d'apparence sebacée'.

Much discussion occurred as to the nature of the cysts. Garrè,[17] for example, considered that they were due to implantation, which view was accepted by almost all writers, and that various appearances could be found according to whether the displaced epithelium retained its connection with its nerves and blood-vessels. If this last pertained, then papillæ remained; but if the connection were lost, then only squamous epithelium developed from the transplanted cells. Experimental work on the growth of epithelium after transplanatation, particularly that of Kaufmann,[26] was quoted in support of the implantation view. On the other hand, Franke[15] pointed out

that a number of cases were not associated with trauma, and deduced that the cysts were due to the late growth of latent embryonal cells.

During this time other hypotheses had been suggested, and the terminology dependent on these used, such as 'pearl tumours' ('cholesteatomata')[19] and 'atheromatous tumours'.[28] One writer[56] spoke of 'heterotopic atheromatous development'. Other terms, which are, however, merely modifications of those already given, are 'epidermal cyst',[1] 'dermal cyst',[2] and 'kystes dermoides traumatiques'.[33] As already stated, they are also frequently referred to as 'implantation cysts'.

During the last thirty years there have been a number of references to these cysts in French, German, Italian, and Russian literature, but there has been a curious silence in English writings, the only statements being those found in text-books or incidental references in papers dealing with general problems.[37] Many of the references are to 'traumatic epidermoid cysts', but it is proposed to show that the term 'post-traumatic' would be more satisfactory.

CLINICAL CHARACTERISTICS.

The patients who develop these cysts almost always follow an occupation in which the hands and fingers are liable to trauma, e.g., labourers, carpenters, gardeners, etc. They may develop in individuals who support themselves by means of sticks, e.g., in the case of partial paralysis. Some patients who do not follow arduous occupations develop cysts after injuries, e.g., street accidents.

The type of trauma is of special interest. In the majority of cases following trauma reported in the literature the injury has been a perforating wound or a crush with laceration of the skin. Though such conditions were present in six of the present series, an important observation was that six cases followed non-perforating wounds—jars, non-lacerating crushes, and such traumata.

Absence of trauma in some cases (seven in the present series) presents a serious problem, since cysts identical with the post-traumatic ones occur without history of injury. In many cases, however, the occupation makes the occurrence of traumata almost certain and also the overlooking by the patient of traumata in one particular spot likely. This leaves very few cases in which an injury does not appear to have preceded the cystic development. The cases which form the basis of this paper may be classified as follows:—

No history of injury but a break of the skin	1 *Case* 1
No history of injury	7 including *Cases* 2 and 3
History of injury without breaking of skin	6 including *Cases* 4, 5, 6, and 7
History of injury with breaking of skin	2 including *Case* 8
History of injury with perforation of skin	4 including *Cases* 4 and 9
Total	20 cysts, 19 cases

The age of the patients falls between the second and the seventh decades. The average age in this series was 41; the youngest was 18 years and the oldest 64 years. Johnson[24] described a cyst in a patient aged 7½ years. Males are most commonly affected (16 out of 19 cases), but this, like age, is probably subsidiary to trauma.

A most important feature is the latent period between the injury and the onset of the development of the cyst. The latent period may result in the patient's forgetting the injury. In those cases where the injury occurs during work, the necessity for correlating such cysts with the injury for insurance purposes is obvious. The cysts commence to develop any time from a few months up to several years after the injury. This latent period is emphasized by the term 'post-traumatic epidermoid cyst'. Frequently a small nodule or thickening is present at the site of the injury, and this remains until, after some time, the cyst commences to enlarge. Once commenced, the enlargement is rapid, so that a cyst may become 1½ to 2 in. in diameter in less than three months. There is seldom any pain associated with the cysts. Tenderness may be present during the growing period.

Examination of the cyst reveals a rounded, sometimes lobulated, semi-fluctuant or elastic mass occupying some portions of the palmar aspect of the fingers or hand. Cysts of the finger are almost invariably ovoid. They may be adherent to the skin or the subjacent structures, e.g., tendon, or to both. On the other hand, they may be free of these structures, though the size and tenseness may prevent such freedom from being demonstrated.

If they are aspirated, white greasy material will be obtained containing cholesterol crystals in large amount and a little fat.

They rarely become infected, but they may burst externally as the result of further injury, as happened in one case of this series.

Diagnosis is usually easy. If there is a history of injury or a scar, a 'fibroma' round a foreign body must be considered. Usually this is a much harder nodule, but occasionally the diagnosis is not complete until the nodule has been removed. In the absence of any injury, ganglion or tumour of the tendon-sheath must be included in the differential diagnosis. Usually, however, the traumatic cysts are much more superficial than other cysts or nodules.

Removal of these cysts is usually easy. They separate readily from the surrounding tissues.

Complications.—Cysts similar to those occurring in the pulp of the finger may be found also in the phalanx. The relationship of these to the cysts in the soft tissues of the fingers and hand is often not evaluated adequately, as shown by the use of such phrases as 'sebaceous cyst of a phalanx'[22]; "at some distant period, a deep puncture wound of the end of the thumb must have carried epithelial cells into the phalanx . . ."; "unfortunately no history of such accident could be obtained". The general interrelationship of the bone and subcutaneous cysts is well discussed by Behrens.[4]

In some cases the cyst of the phalanx follows a perforating injury. In that described by Friedländer[16] the injury was a shell wound, and subsequently Professor Gruber, of Göttingen, demonstrated the presence of epithelial masses occurring in the tissues down to the bone. That the injury resulted in transplantation of tissue here seems to be probable. Even in this case the relationship to the perforating trauma is not absolutely definite, since the cyst did not become apparent until after a second injury (blow by a hammer).

MACROSCOPIC APPEARANCE.

The cysts are usually rounded or ovoid, particularly those in the fingers. Cysts of the palm may be less regular in outline (*see Fig.* 25), having evaginations in various directions whose form is controlled by the surrounding muscles and other tissues.

The wall varies from $\frac{1}{8}$ in. to $\frac{1}{16}$ in. in thickness, usually uniform throughout, but in the larger examples the thickness varies in different parts. Frequently the thickest portion is that nearest the skin, and this part also is tougher owing to keratinous material.

The inner aspect is rough in some parts, smooth in others, depending on whether, after removal of contents, some are still adhering to it (*see Fig.* 28). Laminated keratin is strongly adherent and can only be removed by tearing the wall.

The contents, though superficially resembling sebaceous material, are morphologically, microscopically, and chemically different. Macroscopically they are more gritty and less greasy, contain definite keratin masses, and possess a crystalline sheen.

MICROSCOPIC EXAMINATION.

The cysts consist of a fibrous wall with an inner lining. The fibrous wall varies in thickness and density. In some cases it is merely dense fibrous tissue (*Fig.* 32); often relatively acellular and hyalinized (*Figs.* 33, 34). Thin-walled blood-vessels run for considerable distances in the wall. Nearer the cavity it becomes more cellular and contains numerous cholesterol crystals. Smears of the contents show the typical flat crystals with re-entrant angles.

FIG. 32.—Photomicrograph of portion of a cyst wall showing the structure of the connective-tissue lining. (× 70.)

FIG. 33.—Photomicrograph of portion of the wall of an epidermoid cyst. There is no definite lining and the cyst contents are in direct contact with connective tissue. (× 85.)

In the immediate neighbourhood of the cyst wall there are numerous blood-vessels and nerves. Groups of cells which are difficult to identify are

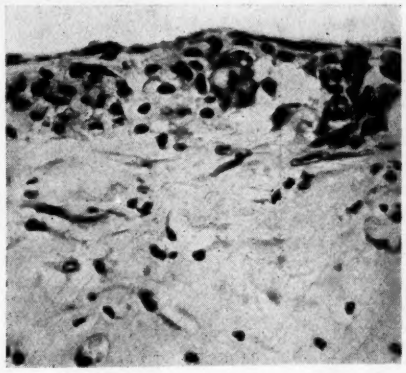

FIG. 34.—Photomicrograph showing the layer of flattened cells on the surface of the connective tissue. (× 180.)

also found (*Fig.* 35). In a few cases I have been able to identify them as epithelial cells. A number of authorities regard them as being groups of sudoriferous gland cells.

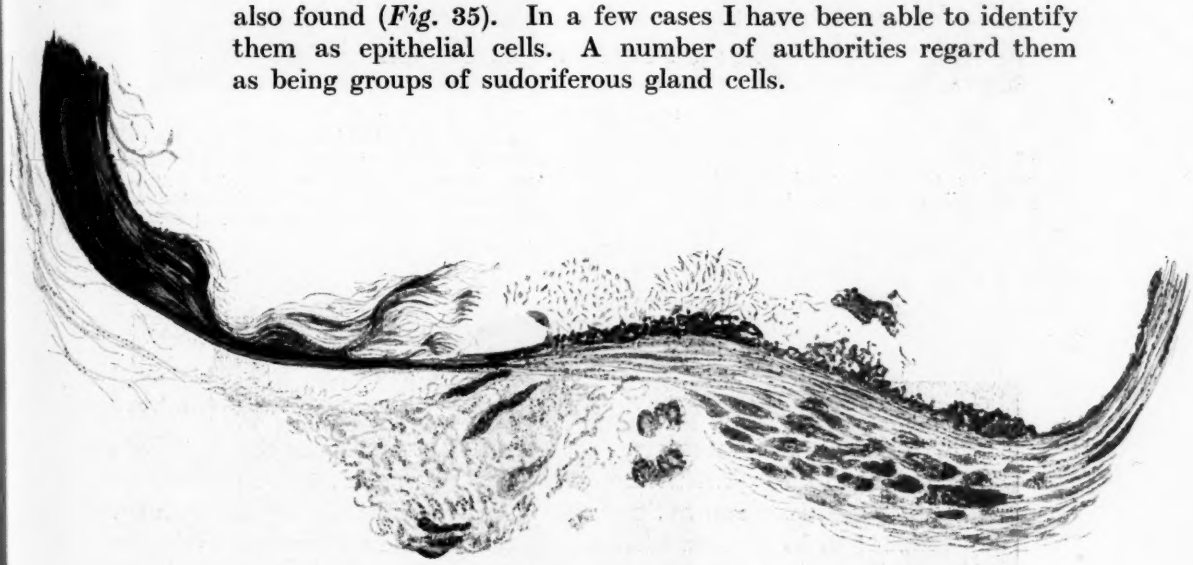

FIG. 35.—Drawing of part of a section of an epidermoid cyst showing portion of the wall lined by squamous epithelium which is forming a large amount of keratin, and the remainder lined by connective tissue containing foreign-body giant cells.

The lining is in part squamous epithelium and in part connective tissue (*see Fig.* 28). The connective-tissue lining shows (in paraffin section) numerous spaces, and surrounding these are foreign-body giant cells of varying sizes and shapes (*Fig.* 36). In some sections polymorphonuclear leucocytes are numerous, though their significance is doubtful. No evidences of bacteria are to be found in sections or contents of the cysts. In some areas the cells of the connective tissue are invading the contents of the cyst (*see Fig.* 33), and such areas show all gradations (*see Fig.* 36) to other parts where the

FIG. 36.—*Case* 1. Photomicrograph of portion of the wall of the cyst showing the cholesterol crystals and giant cells in the wall. (× 150.)

FIG. 37.—Photomicrograph of portion of the wall showing excessive keratin formation. Cysts of this type were, no doubt, the reason for the term 'cholesteatoma' which was applied to these cysts. (× 26.)

FIG. 38.—Low-power photomicrograph showing an island of squamous epithelium in the wall. (× 18.)

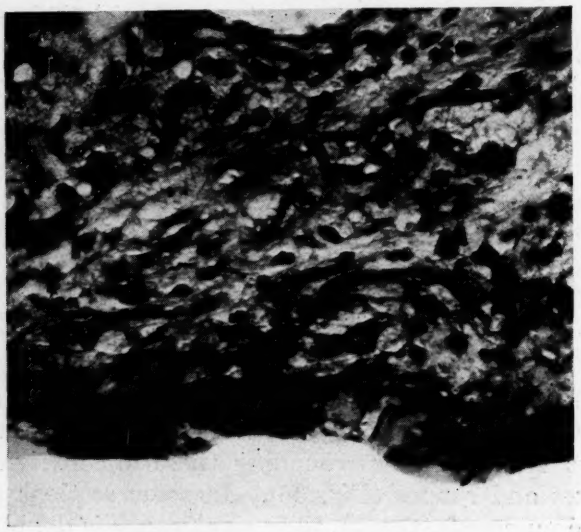

FIG. 39.—Photomicrograph showing the epithelium in a part where it appears to be developing. Some of the cells are columnar in form. (× 405.)

connective tissue is covered by a definite layer of flat cells (*see Fig.* 34). On two occasions I have examined cysts which appeared to be of the same type, as far as could be determined by clinical and macroscopic examination, which possessed no epithelial lining at all, but were lined entirely by the connective tissue.

The well-developed epithelium has a definite basal layer of cuboidal cells, several layers of prickle cells, one or two layers of pigmented cells, and superimposed keratin (*see Fig.* 30). The amount of keratin is often large, giving rise to the use by some of the older writers of the terms 'pearl tumour' or 'cholesteatoma' (*Fig.* 37). Papillæ are very seldom present. They are pictured by Garrè[17] and Nicholson,[37] and I have observed them in a cyst in the foot. The squamous epithelium may end abruptly (*see Fig.* 29), but it often gradually fades into non-epithelialized areas (*Fig.* 38). Islets of epithelium may be found in various parts of the wall (*Fig.* 38).

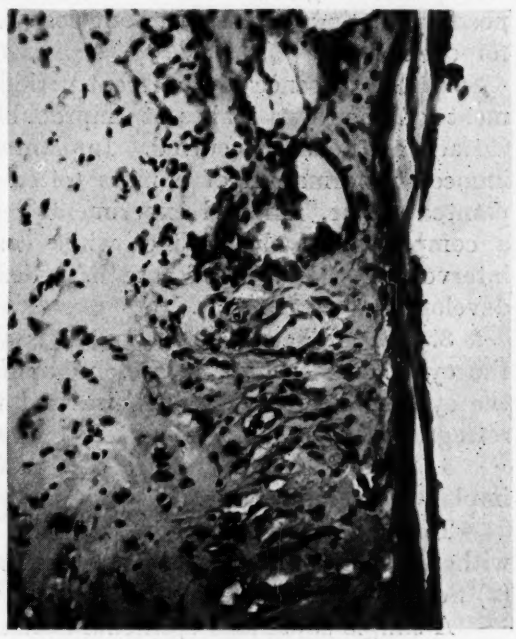

FIG. 40.—Photomicrograph showing the wall with spaces and giant cells in the connective tissue, which is covered by a very low poorly developed squamous epithelium forming keratin. (× 150.)

All of the epithelium is not typically squamous. Certain of the epithelial islets consist of a flattened squamous epithelium. Some of the cells in such areas are columnar (*Fig.* 39), and some of the epithelium, though only two or three cells thick, produces keratin (*Fig.* 40).

It is usually stated that these cysts are never completely epithelialized, but always show an area of connective tissue where absorption of the epithelial secretion is apparently occurring. This has been my experience in all but two cases, in which every part of the wall examined possessed the squamous epithelial lining.

Nature of the Contents.—The contents of the cysts differ from those of sebaceous cysts and from those completely lined by squamous epithelium. It is usually stated that in sebaceous cysts there is a considerable amount of fat, fatty acids, and a small proportion of cholesterol. In the traumatic cysts the proportion of cholesterol is very high and the amount of fat very small (*see Case* 1). There is also a considerable proportion of keratin.

HYPOTHESIS OF MODE OF FORMATION OF THE CYSTS.

The principal hypothesis accepted at the moment is that postulated by most of the older writers, i.e., implantation of epithelium. This opinion has suffered minor alterations, but the underlying idea remains. Figures

illustrating the supposed sequence of events are to be found in various papers, e.g., those of Garrè[17] and Le Fort.[33] It is possible that this is the explanation for some cases but not for all. The claim for this view depends on three observations: (1) A perforating wound sometimes precedes the development of the cyst; (2) The cyst is lined by squamous epithelium; (3) Experimental implantation of skin results in the formation of an epithelium-lined cyst. The arguments which may be raised against this view are:—

1. In many cases the injury is not of the perforating type, and a considerable number of cases do not give a history of trauma. It is unlikely that perforating injuries would be overlooked, but smaller, non-perforating, possibly jarring injuries without loss of continuity of the surface might be forgotten.

2. The presence of the latent period between the injury and the development of the cyst makes it improbable that actual implantation of the surface epithelium occurred. Implantation of tissue usually results in the immediate formation of a mass (often cystic) arising by growth of the implanted tissue. Animal experiments[26] result in the formation of a cyst in a comparatively short time, while considerable periods, even years, may intervene in the type of case here described between the injury and the development of the cyst.

3. The method of development is also peculiar. After the latent period the cyst becomes large relatively rapidly. In cases of known implantation the cysts come to a definite size and then grow more slowly or may even retrogress.

4. The epidermoid nature of the wall does not necessarily support the implantation hypothesis.

Two types of epithelium may be found: (1) A squamous epithelium without papillæ—hence the term 'epidermoid as applied to these cysts; and (2) Squamous epithelium with papillæ, which is uncommon.

A simple squamous epithelium arises so readily from epithelia of various types that the mere presence of tissue showing squamous characters does not indicate the origin from skin. Chiari has shown that certain subcutaneous cysts arise from the glands in the skin. Even the squamous epithelium with papillæ is not inevitably derived directly from the overlying skin. However, even if those cysts which are so lined are regarded, from the nature of the epithelium, as due to implantation, such cases do not always give a history of perforating injury.

Thus the evidence, at first sight so strongly in favour of the implantation hypothesis, actually is feeble and does not uphold the view.

Many curious forms of epithelium are found in these cysts. Usually it is stated that the squamous epithelium becomes flattened by pressure—a process, in view of the growth of cells under considerable pressures, and because such pressures are hydrostatic, difficult of explanation. On the other hand, the presence of columnar cells in some parts (*see Fig.* 39) and the small areas of well-developed epithelium tailing off into non-epithelialized parts of the wall without any evidence of degeneration in these areas, suggests that the epithelium has arisen secondarily. This is also supported

by the appearance of the epithelium in places where it is poorly developed (*see Figs.* 38, 40). The problem, then, is the origin and nature of the epithelium.

Origin of Epithelium. — There are three possible modes of epithelial development: (1) By implantation of whole skin; (2) By separation of some few cells of the deeper layers of the epithelium; (3) By development from some other source.

1. This method of formation has been considered already.

2. This suggestion is similar to that of Garrè in which the implanted epithelium has lost its connection with nerves and vessels. It will not explain those cases, however, in which the injury is slight or where it is an irritation rather than definite injury. It would surely require considerable force to project epithelial cells for several millimetres, in some cases, through the dense fibrous connective tissue.

One curious feature of epidermoid cysts is the presence of a definite layer of connective tissue between the cyst and surface epithelium, the papillæ not being distorted by presence of the cyst. This suggests that the cyst commences to form in the deeper layers of the dermis or in the subcutaneous tissues.

3. The development of the epithelium from sudoriferous glands is a satisfactory theory explaining most of our observations.

In 1905 Pels-Leusden[39] made the suggestion that the epithelium did not arise from the surface epithelium, and concluded that this epithelium probably arose from the cells of the sudoriferous glands and their ducts. (The absence of sebaceous glands from the palm of the hand has already been noted.)

Examination of the walls of cysts shows that the squamous epithelium frequently develops first, or at least is to be found, in that part of the wall near the skin, and examination of the wall in this region shows some sudoriferous glands. Le Fort[33] mentions the occurrence, in the neighbourhood of the wall, of cells which, although he regards them as displaced squamous epithelium, are probably of gland origin. Such groups of cells are to be found in the neighbourhood of the walls of most cysts. Glands and cell groups occur mainly in that portion of the wall of the cyst which is near the skin. In two cases of this series sudoriferous glands were particularly numerous.

The mode of development is probably as follows: The injury results in a hæmatoma,[9] or in some cases probably a chronic inflammatory focus (traumatic in origin) resulting in the formation of a cyst (*Case* 5). This cyst at first contains fluid and degenerating material. It may remain in this form, or even retrogress slightly, during several months. The presence of the cyst, possibly the irritation due to its contents, causes proliferation of the sudoriferous glands in the neighbourhood. Some of these reach the surface of the cyst, where they proliferate—first as columnar cells, then they rapidly stratify and keratinize. An alternative is that some of the cells of the glands are incorporated in the original injured area, and grow, thus forming a cyst. At present it is not possible to prove either suggestion.

It is when the epithelium forms that the cyst commences to grow in size, probably owing to the accumulation of the products of the epithelial activity.

It is probable that with further information it may be necessary to modify the view of the origin of the epithelium, but the important feature is that the cysts are not always due to 'implantation' of skin.

SUMMARY.

1. Cysts of the palmar aspect of the hand and fingers arising after trauma and lined by squamous epithelium are common.

2. The trauma is not necessarily of perforating character; jarring injuries produce a similar result. In a certain number of cases no history of injury is obtainable.

3. There is usually a latent period between the injury and the development of a cyst.

4. The term 'post-traumatic epidermoid cyst' is suggested as emphasizing this feature.

5. The cyst often develops rapidly once it commences.

6. The cysts are benign and easily removed.

7. The squamous epithelium lining them, in the majority of cases, does not arise by implantation from the skin.

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AN INVESTIGATION OF 742 CASES OF HÆMATURIA.

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A STUDY has been made of 742 consecutive cases of hæmaturia which attended the Genito-urinary Department of the London Hospital under the care of Mr. Hugh Lett during the years 1924–30. The majority were treated entirely in the Out-patient Department; the remainder were admitted to the wards either directly or after a preliminary investigation in the Out-patient Department.

The object of this study was to find out the various causes of hæmaturia, and to discover, if possible, what happened to those cases that were unexplained in spite of investigation. Letters were written to all patients in whom the bleeding had not been satisfactorily explained, to find out what had happened to them, and, if necessary, they were asked to attend for further investigation.

The paper is divided into three main sections: (1) A general consideration of the causes of hæmaturia, sex incidence, age incidence, severity of the bleeding, and the common causes thereof. (2) A consideration of the various conditions giving rise to hæmaturia; the relative importance of the main symptoms is evaluated. (3) Consideration of the unexplained cases, with the results of the follow-up investigation.

Patients in whom red blood-corpuscles could be found only on microscopical examination of the urine are not included in the investigation. The presence or absence of hæmaturia was noted when the history was taken. The routine investigation included the clinical testing of the urine in the department, and examination of twenty-four-hourly and sterile specimens in the clinical laboratory whenever necessary. An X-ray examination of both kidneys and bladder was made as a routine. Every case was examined with the cystoscope unless there was some definite contra-indication. Urethroscopy was performed where necessary. If the case required it, the patient was admitted into hospital for pyelography, renal efficiency tests, and any other necessary investigations. It must be mentioned that these cases attended this department before intravenous pyelography was available for investigation.

The two sexes have been studied separately according to the severity of the hæmaturia and grouped as follows:—

Group A.—When hæmaturia was the presenting symptom.

Group B.—When hæmaturia was an important symptom.

Group C.—When hæmaturia had occurred, but was slight and formed merely an incident in the history.

Fig. 41 is a chart to illustrate these groups and to indicate the various causes of hæmaturia.

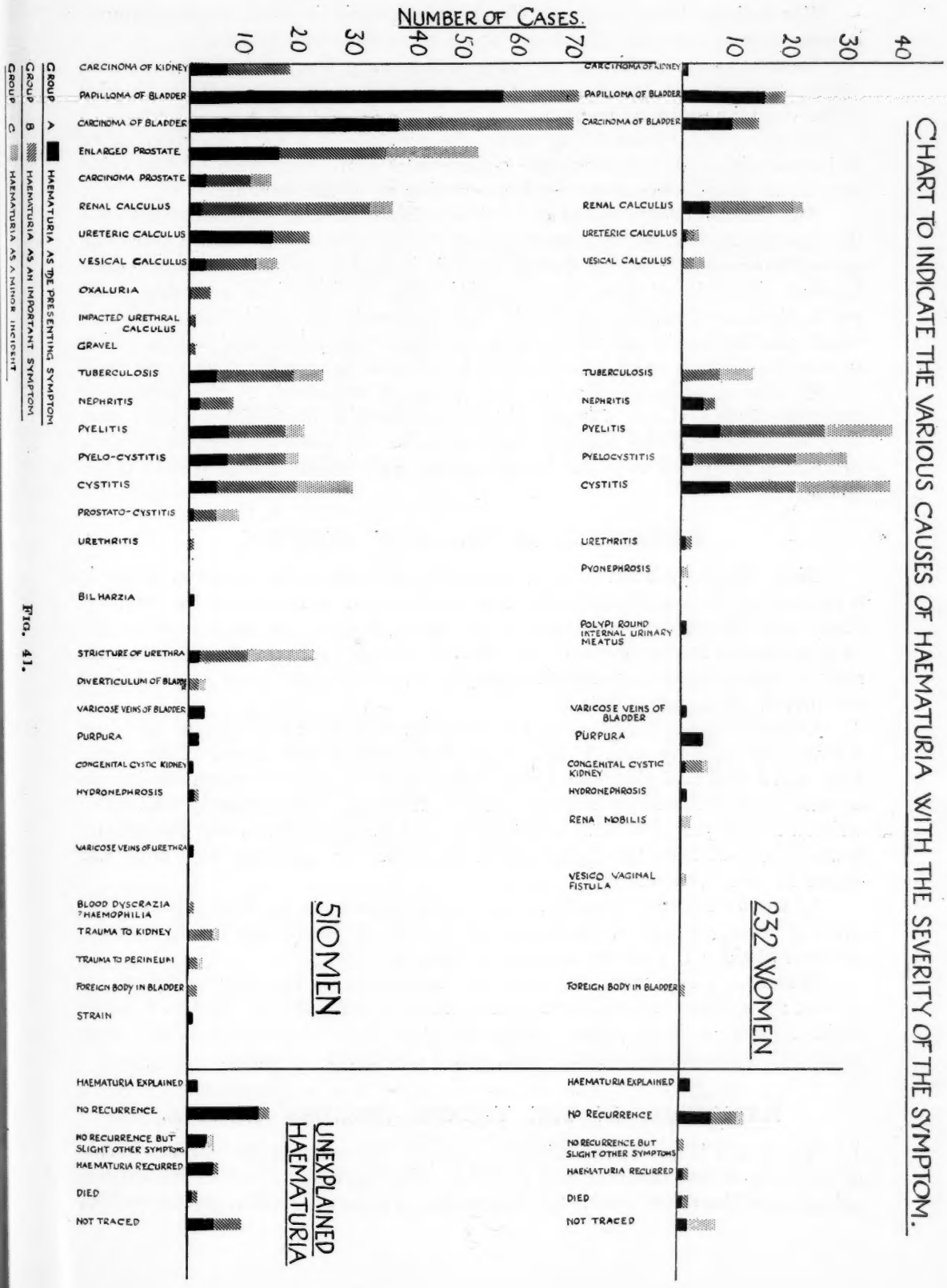
CHART TO INDICATE THE VARIOUS CAUSES OF HAEMATURIA WITH THE SEVERITY OF THE SYMPTOM.
NUMBER OF CASES.
10 20 30 40 50 60 70
10 20 30 40
GROUP A HAEMATURIA AS THE PRESENTING SYMPTOM
GROUP B HAEMATURIA AS AN IMPORTANT SYMPTOM
GROUP C HAEMATURIA AS A MINOR INCIDENT
CARCINOMA OF KIDNEY
PAPILLOMA OF BLADDER
CARCINOMA OF BLADDER
ENLARGED PROSTATE
CARCINOMA PROSTATE
RENAL CALCULUS
URETERIC CALCULUS
VESICAL CALCULUS
OXALURIA
IMPACTED URETHRAL CALCULUS
GRAVEL
TUBERCULOSIS
NEPHRITIS
PYELITIS
PYELO-CYSTITIS
CYSTITIS
PROSTATO-CYSTITIS
URETHRITIS
BILHARZIA
STRICTURE OF URETHRA
DIVERTICULUM OF BLADDER
VARICOSE VEINS OF BLADDER
PURPURA
CONGENITAL CYSTIC KIDNEY
HYDRONEPHROSIS
VARICOSE VEINS OF URETHRA
BLOOD DYSCRAZIA ?HAEMOPHILIA
TRAUMA TO KIDNEY
TRAUMA TO PERINEUM
FOREIGN BODY IN BLADDER
STRAIN
510 MEN
CARCINOMA OF KIDNEY
PAPILLOMA OF BLADDER
CARCINOMA OF BLADDER
RENAL CALCULUS
URETERIC CALCULUS
VESICAL CALCULUS
TUBERCULOSIS
NEPHRITIS
PYELITIS
PYELOCYSTITIS
CYSTITIS
URETHRITIS
PYONEPHROSIS
POLYPI ROUND INTERNAL URINARY MEATUS
VARICOSE VEINS OF BLADDER
PURPURA
CONGENITAL CYSTIC KIDNEY
HYDRONEPHROSIS
RENA MOBILIS
VESICO VAGINAL FISTULA
FOREIGN BODY IN BLADDER
232 WOMEN
HAEMATURIA EXPLAINED
NO RECURRENCE
NO RECURRENCE BUT SLIGHT OTHER SYMPTOMS
HAEMATURIA RECURRED
DIED
NOT TRACED
UNEXPLAINED HAEMATURIA
HAEMATURIA EXPLAINED
NO RECURRENCE
NO RECURRENCE BUT SLIGHT OTHER SYMPTOMS
HAEMATURIA RECURRED
DIED
NOT TRACED

Fig. 41.

Conclusions drawn from the Chart.—Hæmaturia is much more common in men than in women; the proportion is more than two to one.

Inflammatory conditions of the genito-urinary tract are the commonest causes of hæmaturia in women, whereas papilloma or carcinoma of the bladder is the commonest cause in men.

In older men, from 50 upwards, the prostate is a very common cause of hæmaturia—either from simple enlargement with congestion of the veins over it, or much less commonly from carcinoma of the prostate.

The inflammatory conditions occur earlier in life, especially between the ages of 20 and 40, the incidence of this trouble rising rapidly from the age of 20 onwards. In the female sex this is largely accounted for by child-bearing. Pyelitis of pregnancy, cystitis due to infections resulting from parturition, a subsequent cystocele, together with the short female urethra which predisposes to ascending infection, constitute important factors which favour the occurrence of inflammatory troubles in women between these ages.

On the other hand, if a man complains of hæmaturia as the presenting symptom there is almost a 50 per cent chance that it is due to either a papilloma or a carcinoma of the bladder—in this series, 97 cases of hæmaturia as a presenting symptom were due to this cause, and 100 cases were due to other causes.

HÆMATURIA AS THE ONLY SYMPTOM.

Men.—In the case of a man, if hæmaturia is the *only* symptom, there is a two to one chance that it is due to a papilloma or carcinoma of the bladder. There were 65 cases of hæmaturia as an only symptom; of these 44 were due to a papilloma or carcinoma of the bladder, and 21 were due to other causes, and, in spite of full investigation, only 9 of these cases could be explained completely when investigated.

Of the 12 unexplained cases, 1 was proved later to be due to renal calculus, 6 remained perfectly well, 1 died eight years later of carcinoma of the prostate, and 3 said that they had had recurrences of the hæmaturia on one or two occasions after attending hospital. These, however, were perfectly well when written to one year, four and a half years, and five years later, and though the hæmaturia had been 'unexplained' at the time, the patients were none the worse in consequence.

Of the 9 explained cases the causes of hæmaturia were: Prostatic enlargement 3 cases, pyelitis 2, carcinoma of prostate 1, renal calculus 1, varicose veins of bladder 1, varicose veins of urethra 1.

Women.—There were 10 cases of hæmaturia as an *only* symptom in women: Papilloma of bladder 3, renal calculi 2, nephritis 1. And of 4 unexplained cases, 2 later passed stones (though X-ray examination had been negative), 1 remained perfectly well, and 1 could not be traced.

HÆMATURIA IN THE VARIOUS DECADES OF LIFE.

The graph (*Fig.* 42) indicates the relative frequency of the various causes of bleeding at the different age periods. The common causes of hæmaturia are grouped together thus: (1) *Inflammatory causes* (pyelitis, pyelo-cystitis,

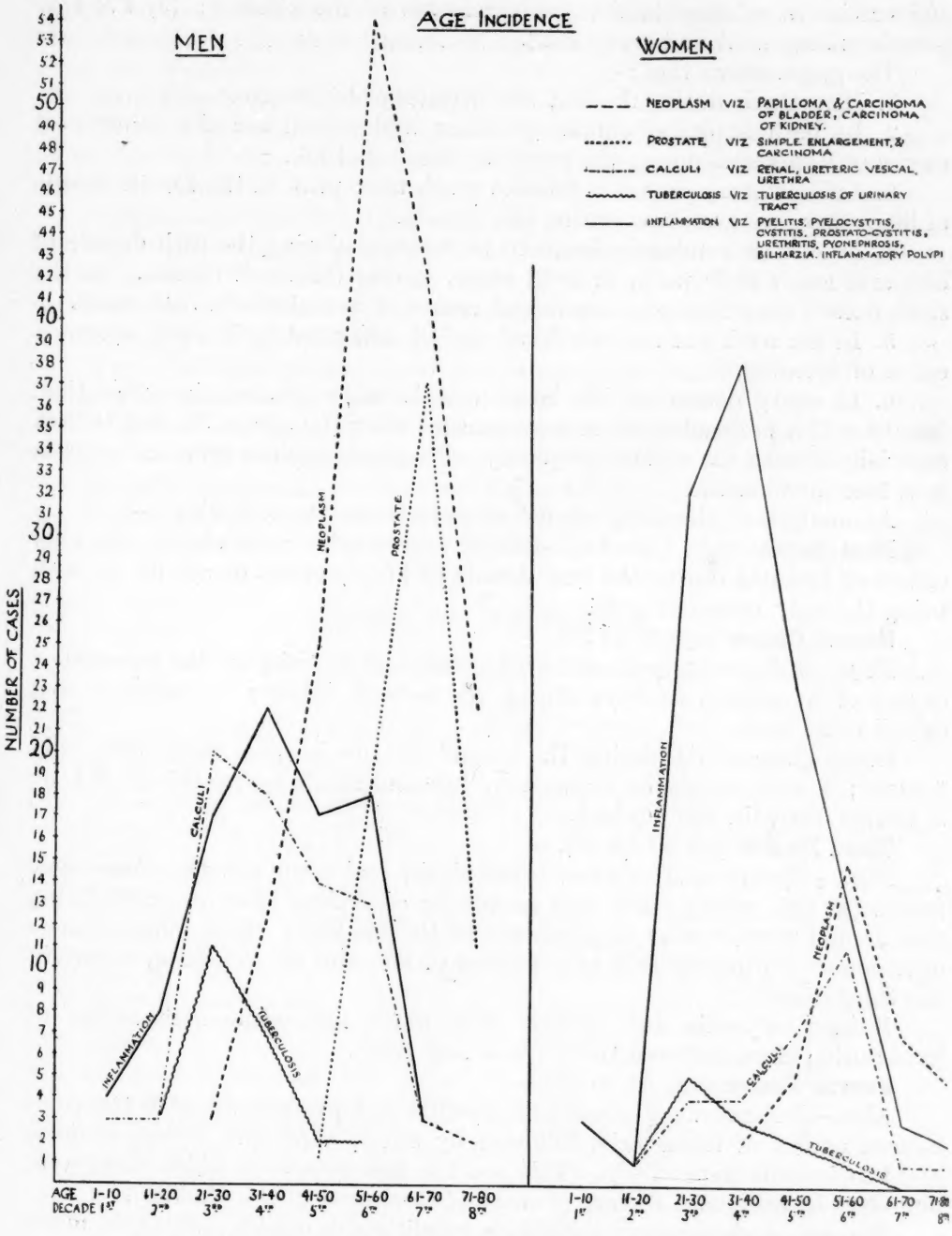
AGE INCIDENCE
MEN
WOMEN
NEOPLASM VIZ PAPILLOMA & CARCINOMA OF BLADDER, CARCINOMA OF KIDNEY.
PROSTATE VIZ SIMPLE ENLARGEMENT, & CARCINOMA
CALCULI VIZ RENAL, URETERIC VESICAL, URETHRA
TUBERCULOSIS VIZ TUBERCULOSIS OF URINARY TRACT
INFLAMMATION VIZ PYELITIS, PYELOCYSTITIS, CYSTITIS, PROSTATO-CYSTITIS, URETHRITIS, PYONEPHROSIS, BILHARZIA, INFLAMMATORY POLYPI
NUMBER OF CASES
NEOPLASM
PROSTATE
CALCULI
INFLAMMATION
TUBERCULOSIS
AGE DECADE 1-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80

FIG. 42.—Graph indicating the relative frequency of the various causes of bleeding at the different age periods.

cystitis, prostato-cystitis, urethritis, pyonephrosis, etc.); (2) *Calculi* (renal, ureteric, vesical, and urethral); (3) *Tuberculosis*; (4) *Neoplastic* (papilloma and carcinoma of the bladder and carcinoma of the kidney); (5) *Prostatic* (simple enlargement and carcinoma).

The graph shows that :—

1. Hæmaturia during the first two decades of life is rare.

2. In both sexes inflammatory causes and calculi are the commonest causes of hæmaturia during the first four decades of life.

3. Inflammatory causes in females reach their peak in the fourth decade of life; there were 38 cases during this decade.

4. Neoplastic conditions begin to be common during the fifth decade of life, and reach their peak, in both sexes, during the sixth decade. In the sixth decade they form the commonest causes of hæmaturia in both sexes.

5. In the sixth and seventh decades of life the prostate is a very common cause of bleeding.

6. In every decade of life hæmaturia is more common in males than females; this preponderance is most marked after the age of 50, and is then especially due to the greater frequency with which bladder growths occur in men than in women.

An analysis of the complete list of cases shows the following :—

First Decade (age 1 to 10).—Calculi and pyelitis were almost the only causes of bleeding during the first decade of life; pyelitis or cystitis or both being the only causes in girls.

Second Decade (age 11 to 20).—

Boys.—Inflammatory conditions (pyelitis and cystitis) are the commonest causes of hæmaturia in boys during the second decade; tuberculosis and calculi come next.

Girls.—Hæmaturia during the second decade is rare, there were only 5 cases; 2 were caused by stone, 1 by tuberculosis, 1 by pyelitis, and 1 by a foreign body in the bladder.

Third Decade (age 21 to 30).—

Men.—Pyelitis and cystitis, tuberculosis, and stone are the commonest causes (in this order). The only neoplastic conditions that occurred during this decade were 3 cases of papilloma of the bladder; there were no cases of neoplasm during the first two decades of life, and the condition is rare in the third decade.

Women.—Pyelitis and cystitis were much the commonest causes of hæmaturia; then followed tuberculosis and stone.

Fourth Decade (age 31 to 40).—

Men.—Inflammatory conditions (cystitis and pyelitis) are still the commonest causes of hæmaturia, followed by stone, papilloma of the bladder, and tuberculosis respectively. This was the first decade in which there were any cases of malignant disease (2 cases of carcinoma of the bladder).

Women.—Inflammatory conditions (pyelitis and cystitis) are again much the commonest causes of bleeding; neoplasm does occur, but is rare.

Fifth Decade (age 41 to 50).—

Men.—For the first time neoplasm becomes the commonest cause of hæmaturia (papilloma and carcinoma of the bladder). Stone and inflammatory

conditions (pyelitis and cystitis), which are about equally frequent, are less common causes, while tuberculosis is rare.

Women.—Inflammatory conditions (pyelitis and cystitis) are still much the commonest etiological factors, stone and growths of the bladder being much less frequent.

Sixth Decade (age 51 to 60).—

Men.—Neoplasm, especially papilloma of the bladder, is the commonest cause; in this decade it is followed by the prostate, with inflammatory conditions third.

Women.—For the first time neoplasm becomes the commonest cause of hæmaturia (especially papilloma of the bladder); then come inflammatory conditions (cystitis and pyelitis), and, thirdly, stone; all three of these conditions occur with about the same frequency in this decade.

Seventh and Eighth Decades (age 61 to 80).—

Men.—Enlarged prostate and carcinoma of the bladder are by far the commonest causes of hæmaturia during these decades; then follow papilloma of the bladder, carcinoma of the prostate, carcinoma of the kidney, and stricture of the urethra with secondary infection. It will be seen, therefore, that the two most important examinations are rectal examination and cystoscopy.

Women.—Papilloma and carcinoma of the bladder are the commonest causes; the condition is much less common in women than in men.

CAUSES OF HÆMATURIA.

The following table shows the relative frequency of the various causes of hæmaturia.

		TOTAL Per cent	MEN Per cent	WOMEN Per cent
Carcinoma of kidney		2·5	3	Less than ½
Papilloma and carcinoma of bladder		23	27	14
Calculi (renal, ureteric, vesical, urethral)		14·5	15	Nearly 13
Tuberculosis		5	Nearly 5	Just over 5
Pyelitis, Pyelo-cystitis, Cystitis, Urethritis, Prostato-cystitis, Pyonephrosis, Bilharzia	Inflammation	25·5	16	46·5
Prostatic enlargement		7	10	—
Carcinoma of prostate		2	Nearly 3	—
Stricture		3	4	—
Unexplained Hæmaturia		9	7	12
SUB-DIVISIONS: Hæmaturia subsequently explained		0·5		
No recurrence of hæmaturia		3·5	Nearly 3	5
No recurrence of hæmaturia but slight other symptoms		0·8		
Hæmaturia recurred		1·3		
Died subsequently		0·5		
No reply received		2·3		

Cystoscopy during an attack of hæmaturia is so valuable that if a patient comes to hospital during the attack of bleeding he should have a cystoscopic examination forthwith, unless there is some definite contra-indication such as

acute cystitis. Only in this way can the source of the hæmorrhage be determined accurately; a carcinoma of the kidney may be detected thus, or some other lesion causing bleeding from one kidney. Or if blood is seen coming from both ureteric orifices, the lesion is bilateral, and probably of medical rather than surgical interest.

Not infrequently hæmorrhage is so great that it is impossible to obtain a view of the bladder; under these circumstances rest in bed is a most valuable method of stopping the hæmaturia. Other aids are the irrigating cystoscope or liquid paraffin as a medium. Sometimes a cystogram is useful.

Marked bleeding from the bladder, or a very 'dirty' bladder, which takes a long time to wash clean, is of course strongly in favour of a bladder lesion rather than of a lesion of the kidneys, and is especially suggestive of carcinoma vesicæ or tuberculosis.

The various causes of hæmaturia are now considered seriatim in the order shown on the chart.

Carcinoma of the Kidney (18 cases: 17 men, 1 woman. Average age 56).—A surprisingly small number of patients proved to be suffering from growths of the kidney, only 2½ per cent of the total, and only 2 of these were under 50 years of age.

Hæmaturia occurred in every instance of renal growth which attended the department: in 8 cases it was the presenting symptom; and in 6 the first symptom. It was usually profuse and recurrent; in only 1 instance was there a single bleeding, and this occurred at the commencement of the symptoms, a whole year before the patient attended hospital.

In 2 cases the growth was associated both with renal calculi and hydronephrosis; it was not possible to say which was the primary condition. The possibility of malignancy should be remembered in patients showing marked cachexia, profuse hæmaturia, and a big kidney with stones showing in the X-ray.

Characteristically blood was seen coming from the ureter on the affected side only. Pyelography may show either a filling defect, or sometimes may be an apparent failure because no opaque fluid enters the renal pelvis, which is blocked by growth or blood-clot.

Papilloma and Carcinoma of the Bladder.—Of all cases of hæmaturia 23 per cent were explained by bladder growth (in men 27 per cent, and in women 14 per cent). Neoplasm of the bladder is the commonest cause of hæmaturia in men, and much the commonest cause of it as the presenting symptom. Moreover, bleeding was the most marked feature of all bladder growths, and was almost always the first manifestation. In papilloma of the bladder it was the *only* symptom in 41 per cent, and the presenting symptom in 63 per cent of cases. In carcinoma the percentages were 8 and 47 respectively.

Carcinoma occurs at a later age period than papilloma, the average age for papillomata being 52 and for carcinoma 61 years; both conditions are very rare under the age of 30. Bladder growths are much less common in women than in men; for papilloma the proportions are about 1 woman to 4 men and for carcinoma 1 to 5.

Carcinoma of the bladder and prostatic enlargement are often associated, and may produce somewhat similar symptoms, so that unless cystoscopy is performed the former may masquerade as a simple prostatic hypertrophy.

Enlarged Prostate.—Ten per cent of all cases of hæmaturia in men are due to prostatic enlargement, and if carcinoma of the prostate is included, the percentage becomes nearly 13.

There were 130 cases of hæmaturia in men over 60 years of age; 39 of these were due to simple prostatic enlargement (30 per cent), and 42 were due to carcinoma of the bladder (32 per cent), the percentage for the two conditions being about the same. Of all cases of hæmaturia in men over 60, 84 per cent are caused by the following conditions:—

Simple prostatic enlargement ..	39 cases	30 per cent	37 per cent
Carcinoma of the prostate ..	9 „	7 „	
Papilloma of the bladder ..	15 „	11 „	43 „
Carcinoma of the bladder ..	42 „	32 „	
Stricture of urethra (plus complications)	5 „	4 „	

The hæmorrhage may be associated with the usual signs and symptoms of prostatic enlargement, or it may be almost the only symptom. The amount of blood varies greatly: there may be a few streaks only, or the urine may be a deep red, and clot retention may result.

Cystoscopy shows that the bleeding is usually due either to engorged veins running over the surface of the prostate or to a very congested mucosa overlying the gland. Bleeding in the former case tends to be more profuse, in attacks; and in the latter case the hæmorrhage is less and may merely cause streaks of blood in the urine. Characteristically the bleeding occurs especially at the end of the act of micturition, but this is by no means invariable.

Blood in the urine may result from the complications arising from prostatic enlargement; 8 cases were complicated by vesical calculi, 2 by prostatic calculi, 2 by acute prostatitis, and 2 by cystitis.

Carcinoma of the Prostate.—The hæmaturia in these cases conformed very much to that found with the simple enlargement. There were 15 cases, 2 were complicated by the presence of vesical calculi. The average age of the cases of carcinoma of the prostate was practically the same as that of the cases of simple enlargement.

Renal Calculi (59 cases: 37 men, 22 women).—The maximal incidence was from the age of 20 to 50 in men, and from 40 to 60 in women, but no decade was exempt.

The great majority (46 of 59 cases) had hæmaturia falling under the heading of *Group B*; it was usually associated with renal pain and conformed to text-book description. Occasionally, however, bleeding was the first symptom (3 men and 2 women), and in others (1 man and 3 women) it was the only symptom. In addition there were 4 cases in which the bleeding was unexplained at the time but later proved to be due to calculi. These patients had no pain, and the original X-ray examination was negative.

The severity of bleeding varies considerably; it may be slight or so severe as to cause anæmia. One patient came to hospital with bleeding which was

believed to be due to an injury; he had slipped and hurt his side. A routine X-ray demonstrated the cause of the 'injury,' which was a large renal calculus that had remained latent up till that time. The oft-repeated advice to X-ray accident cases again proves useful.

Ureteric Calculi (25 cases: 22 men, 3 women).—Bleeding was usually associated with and overshadowed by pain; it was, however, the presenting symptom in one case and the first symptom in another.

Vesical Calculi (20 cases: 16 men, 4 women. Average age: men 44, women 35).—Hæmaturia was usually only slight, though it may occur on several occasions, especially at the end of micturition. In 3 cases only was it the presenting symptom, all 3 being men of somewhat advanced years.

Urethral Calculus.—There was only 1 case of urethral calculus; it was a migratory calculus, which had formed in the kidney, and caused bleeding when it became impacted in the urethra.

Gravel.—An infant aged 1 year and 9 months had hæmaturia associated with pain and frequency produced by the presence of gravel. The attack was not repeated and the child was well three years later.

Tuberculosis (38 cases: 25 men, 13 women. Average age: men 30, women 36).—Five per cent of all cases of hæmaturia were due to tuberculous infection. Amongst the 2000 patients who attended the Genito-urinary Department, 77 had tuberculosis of the genital or urinary tract. Of these 38, or almost 50 per cent, had hæmaturia.

Although bleeding was usually associated with painful frequent micturition, occasionally it was the presenting symptom, and in several others the first symptom noticed was blood in the urine. Bleeding from a tuberculous kidney may precede bladder symptoms by months or even a year, the patients having no symptoms in the interval, and this should always be remembered especially when dealing with young adults.

Hæmorrhage may occur either from the kidney or bladder; a tuberculous bladder is frequently contracted, very intolerant, and bleeds readily if over-distended, so making cystoscopy difficult, and any overfilling causes bleeding which obscures the view.

Nephritis (14 cases).—These must be regarded as stray examples of nephritis, showing how careful the urologist must be to exclude patients who are usually treated by a physician. The number is not a true index of the frequency of hæmaturia due to nephritis, because most cases of this condition were treated in the Medical Department. Cystoscopy usually showed nothing abnormal; occasionally blood was seen coming from one ureteric orifice, or characteristically from both.

If the routine examination of a case of hæmaturia gives a negative result, the investigation is not complete until a full medical examination has been made, including examination of the blood and fundi and estimation of the blood-pressure.

Pyelitis (58 cases: 21 men, 37 women. Average age: men 28, women 32).—The condition occurs especially during the child-bearing age in women, and in men at about the same age (20 to 40 years). There was no case over 60 years of age.

Hæmaturia due to pyelitis is not uncommon. Sometimes a profuse

bleeding attack may occur at the beginning of the trouble, the attack may recur, or small amounts of blood may be passed at intervals.

In quite a number of cases hæmorrhage was the presenting symptom—7 men and 7 women. Bleeding is often profuse, and may be almost the only symptom, pain and frequency being slight or absent. It seems that the passage of blood in the urine may give rise to some frequency which ceases with the hæmaturia. On examination of the urine pus was present in small amount, often only detectable with the microscope, but sometimes quite obvious. Colon bacilli were usually found. Rarely, there may be simply leucocytes in a sterile urine. There are various possible sources of error, such as the accidental presence of antiseptics in the sterile specimen and mistakes in technique; nevertheless these cases appear to merge into the group of 'unexplained' hæmaturia.

Cystoscopy in cases of pyelitis shows anything from a marked cystitis (in which case it is classified as pyelo-cystitis) to a normal bladder and ureteric orifices. The negative findings may be due to the fact that the inflammation has subsided, leaving nothing more than some injection of the vessels. The typical picture shows a red œdematous ureteric orifice, with a varying amount of inflammation of the bladder wall around. Often the findings may be simply œdema of one or both ureteric orifices, with congestion of the base of the bladder (trigonitis), or petechial hæmorrhages may be seen. Blood or turbid urine may be seen coming from one or both ureteric orifices.

Pyelo-cystitis.—The age incidence is the same as and the history similar to that given in cases of pyelitis, except that the bladder symptoms are more marked, though in this group there were 7 men and 2 women who came up with hæmaturia as the presenting symptom. The groups of pyelitis and pyelo-cystitis naturally merge into each other.

Cystoscopic appearances show anything from an intense general cystitis, usually associated with a most intolerant bladder, to a mild basal cystitis, often associated with submucous hæmorrhages similar to those seen in purpura of the urinary tract.

[Conclusions.—Evidently a number of different types of case are classed as pyelitis.

1. There is the typical text-book type of case, seen commonly in the medical wards, acutely ill, with high fever and perhaps a rigor at the onset, marked pyuria, and acute tenderness over the kidney.

2. A milder type attends the out-patient department: the symptoms are mostly of renal character with lumbar pain and frequent micturition; constitutional disturbances are considerably less marked.

3. There is an even milder type in which hæmaturia is marked, pyuria almost absent, and malaise very slight. Indeed, the condition seems to be little more than a renal epistaxis, and it is difficult to decide whether to class the case as one of pyelitis or as one of unexplained hæmaturia. Some of these cases may be due to purpura of the kidney.

These marked differences probably depend largely upon the virulence of the infection and the amount of renal tissue involved.]

Cystitis (68 cases: 30 men, 38 women. The average age for both sexes was 39, but cases occurred at all ages).—A variety of cases fall under the

heading of cystitis, the causes of which are numerous; in many cases the exact etiology is difficult to ascertain, but it is probable that many of them should be classed under the heading of pyelo-cystitis.

Nine cases were considered to be due to cystocele, a common cause of cystitis in women, and one that is often overlooked. Cystocele was present in other cases too, but the connection with the cystitis was not so certain.

Six cases were associated with neuropathic bladder with secondary cystitis (4 men and 2 women); there was a definite spinal-cord lesion in 5 of these. One case must be classed as an ulcer of the bladder; no cause for it could be found.

The hæmaturia characteristically occurred in small amounts, blood being passed at the end of the act of micturition. Often there were shreds of blood only. Sometimes hæmorrhage was profuse. Cystoscopy showed an intense cystitis with engorged vessels and red mucosa, the comparative freedom from pain and frequency being sometimes quite surprising. Pain and frequency usually figure prominently in cystitis, and it is rather surprising that 14 of these cases came to hospital with hæmaturia as the presenting symptom.

Prostato-cystitis and Prostatitis (9 cases).—Bleeding was not profuse; it often occurred at the end of micturition.

Cystoscopy was performed in all but two cases, and showed marked congestion and dilatation of the veins over the prostate, or a basal cystitis; this evidently accounted for the bleeding. In acute cases of prostatitis cystoscopy is contra-indicated.

Urethritis (3 cases: 1 man, 2 women).—Each case was associated with a purulent urethral discharge, most probably of gonococcal origin. The hæmorrhage was at the end of the act of micturition, and was apparently due to associated cystitis. Cases of venereal disease were not treated in the department, and must be regarded as stray cases.

Pyonephrosis.—One case of old-standing pyelitis, and later pyonephrosis, with adhesions kinking the ureter, was associated with very slight hæmorrhage.

Bilharzia.—One case of hæmaturia as a presenting symptom occurred in a boy of 18 years who had previously suffered from bilharzia. A slight injury to the abdomen produced an attack of hæmorrhage.

Polypi round Internal Urinary Meatus.—A woman of 52, with hæmaturia as the presenting symptom, was found to have polypi around the internal urinary meatus; these were most probably inflammatory in nature.

Stricture of the Urethra (23 cases, all men. Average age 47—youngest 21, oldest 72).—Hæmaturia, which was usually only slight and occasional, occurred only in complicated cases and as a result of infection supervening on the stricture—prostatitis, cystitis, calculus formation, and so on.

In some cases there was a long-standing history suggesting stricture, with recent symptoms of cystitis; in others the patient apparently had an acute cystitis without any obstructive symptoms, and the underlying cause of the trouble was only discovered on attempted cystoscopy and confirmed by urethroscopy.

Diverticulum of Bladder (3 cases, all men. Average age 42 years).—Although the diverticula were all congenital, and the youngest patient 31

years old, the longest history was of only a couple of months' duration. The symptoms were produced by complications — cystitis or calculus formation.

Trauma.—All the cases of hæmaturia resulting from trauma occurred in men; 6 patients received injuries in the kidney region, causing bleeding from the kidney; 3 received blows on the perineum and so caused bleeding from the urethra; 1 case was caused by straining during coitus.

Foreign Body in the Bladder.—There were 3 cases of this condition, all in young people; none of them gave any history of the presence of the foreign body until it had been discovered on cystoscopy. The history in each case was one of a subacute cystitis, with considerable bleeding, produced either by the foreign body or by resulting infection. All the cases of foreign bodies in the bladder which attended the department had hæmaturia. The foreign bodies were a pen-holder and a piece of tallow candle, found in the bladders of men of 25 and 19 years of age respectively, and a slate pencil in the bladder of a woman of 19; the last case also had a perivesical abscess.

Hæmaturia from Varicose Veins of Bladder (4 cases: 3 men, 1 woman. Average age: men 53, women 29).—Hæmaturia was the presenting symptom in each case. On cystoscopy the tortuous varicose veins were seen over the base of the bladder. Great caution must be taken in diagnosing these cases, for it is easy to attribute bleeding to an engorged varicose vein of the bladder when it has actually come from a kidney, and the bleeding has ceased before cystoscopy is performed.

In the case of the woman the bleeding occurred especially during pregnancy; she was quite well otherwise, but during two pregnancies she attended with hæmaturia, which was found to come from a large tortuous vein running across the trigone just behind the internal urinary meatus.

One man, who first attended at the age of 66, had such severe bleeding that it was necessary on two occasions to open the bladder and deal with the bleeding point.

Congenital Cystic Kidney (6 cases: 1 man, 5 women. Average age: men 53, women 31).—There was a family history of the complaint in 2 cases. Hæmaturia is a characteristic symptom of this condition and occurred in every case which attended the department. The bleeding occurs intermittently, in attacks, and may be quite profuse; it is often associated with a dull ache in the loins; pyelitis is not uncommon as a complication.

Purpura of the Urinary Tract (6 cases: 2 men, 4 women. Average age: men 27, women 36).—In every case hæmaturia was the presenting symptom; pain was present in 3 out of the 6 cases, but in no instance was it severe. Each gave a history of quite profuse bleeding, lasting from one to eight days; sometimes the attack had recurred.

Cystoscopy showed purpuric spots scattered over the whole bladder; no spots were found elsewhere. *B. coli* was cultured in the urine of 3 of the women; in no case was pyuria present. One man, aged 62, had chronic heart disease, with auricular fibrillation.

Of the 6 cases which could be traced, all remained quite well when inquiry was made from six months to six and a half years after the attacks of hæmaturia. The prognosis is therefore good.

Hydronephrosis.—Of the 3 cases of hydronephrosis (average age 36), 2 gave histories of renal pain with attacks of hæmaturia, and 1 a history of hæmaturia only; there were no other symptoms except an occasional feeling of discomfort in the right side of the abdomen.

Pyuria was present in all the cases, and all were operated on, the clinical findings being confirmed. The bleeding was probably due to congestion and slight infection.

Rena Mobilis.—There was one case of rena mobilis producing typical renal colic which was followed by hæmaturia on one occasion, and another case which was associated with trigonitis and slight hæmaturia.

Varicose Veins of the Urethra.—There was an interesting case of a man with varicose veins of the urethra. He first attended at the age of 14 with a two weeks' history of bleeding from the urethra independent of micturition; there were no other symptoms. Urethroscopy showed a small cluster of varicose veins extending for ¾ in. along the lateral wall of the urethra, and situated 1½ in. from the external urinary meatus. No other abnormality was found. He returned some years later with a recurrence of the trouble; the veins were then cauterized with success.

Vesico-vaginal Fistula.—In one case a vesico-vaginal fistula followed hysterectomy; this was complicated by cystitis and vesical calculus, and hæmaturia resulted.

Blood Dyscrasia (? Hæmophilia).—There was an interesting case of a man of 29 who first attended with a five days' history of hæmaturia followed by an attack of left renal colic (evidently clot colic). The family history was that the grandfather was a bleeder. Both parents were healthy and well. The patient had three brothers; two were well, one had been in hospital twice with hæmorrhage from the kidneys, but no operation had been performed. He had three sisters, all alive and well. The patient himself had had four teeth extracted on different occasions, and the sockets had to be plugged for bleeding each time.

On investigation there were no abnormal physical signs. The urine contained albumin and blood. Cystoscopy showed that blood was coming from the left ureteric orifice. A pylogram of the left kidney was normal. A blood-count and platelet-count were also normal. The blood coagulation time was 3 minutes 30 seconds (normal, 2 minutes 45 seconds).

Eighteen months later the bleeding recurred for five days. Investigations were negative; the bleeding had ceased when cystoscopy was performed. The blood coagulation time was the same as that found on the first occasion. For the last two years he has remained perfectly well.

UNEXPLAINED HÆMATURIA.

There were 66 cases of hæmaturia the cause of which was not explained by investigation (40 men and 26 women). Letters were written to each patient to discover the after-history; 17 could not be traced or did not reply (10 men and 7 women). There are, therefore, 49 cases to be considered. Of these, 4 (8 per cent) proved later to be due to calculi; 27 (55 per cent) had no more trouble of any kind; and 6 (12 per cent) had no more hæmaturia, but slight

other symptoms. Adding these two groups together, 67 per cent remained well. Four (8 per cent) died, the cause of death having no definite connection with the bleeding except perhaps in one instance. Eight (16 per cent) had recurrence of the bleeding; however, all except one of these remained fairly well and none of them attended for further investigation.

The groups are now considered seriatim :—

Inquiry Made: Hæmaturia Explained.—All these 4 cases were due to renal calculi. Hæmaturia had been the presenting and almost the only symptom when they attended hospital. X-ray examination had been negative. Two patients passed stones later; one had a stone removed at operation, and one attended hospital as a result of the inquiry, when further X-ray examination demonstrated the calculus six and a half years after her first attendance.

Cases of Unexplained Hæmaturia which Remained Perfectly Well.—There were 27 patients (15 men and 12 women) in whom the cause of bleeding had not been discovered and who remained perfectly well. The average age of the men was 32 and that of the women 41 years. The cases fell into the following groups :—

Hæmaturia as the presenting symptom ..	13 men	6 women
„ as an important symptom ..	2 „	5 „
„ as an incident	0 „	1 „

All were well, and hæmaturia had not recurred when inquiry was made at an interval of six months to seven and a half years (average time three years) after their first attendance at hospital. The group probably represents a variety of conditions.

Of the 15 men, bacteria were cultured in an otherwise clear urine in 5 cases, and infection may have been responsible. Casts were found in the urine of another. One had slight oxaluria, one a positive Wassermann reaction, 1 refused adequate investigation, and in 6 there was nothing abnormal to be found.

Of the 12 women, bacteria were cultured in an otherwise clear urine in 4 cases, 1 was probably a case of purpura, 1 had a movable kidney, 1 had a few casts in the urine, and in 5 nothing abnormal was found.

Inquiry Made: No More Hæmaturia, but Slight other Symptoms.—There were 6 cases of unexplained hæmaturia who remained well except for slight discomfort (5 men and 1 woman). They represent a variety of conditions, and little importance can be attached to the cases. One case was probably a mild infection, 1 suffered from nocturnal enuresis, 3 had slight backache but were otherwise well, and 1 had some pain following exploratory nephrotomy.

Inquiry Made: Hæmaturia Recurred.—The 8 cases in which hæmaturia recurred are as follows :—

Case 1.—Male, aged 14 when he first attended hospital. On several occasions he had attacks of bleeding, which were seen on one occasion to be coming from the left kidney. Investigations were otherwise negative, and he was well eleven years later—so well, in fact, that he did not wish to attend for any further investigations, although he continued to have hæmaturia about once a year.

Case 2.—Man, aged 28, with symptomless hæmaturia which had recurred on two occasions; he was well two years after attending hospital.

Case 3.—Man, aged 31, who attended with symptomless hæmaturia which recurred two years later. He had no other trouble, and was well three years after the last bleeding.

Case 4.—Man, aged 49. Attended with symptomless hæmaturia; investigations negative, except that he had syphilis. During the next three and a half years he had two recurrences of the bleeding and became blind. He was unable to attend for further investigation.

Case 5.—Man, aged 49. Symptomless hæmaturia, except for one attack of left renal pain (probably clot colic). Investigations showed that on one occasion blood was coming from the left ureter. Pyelograms showed slight bilateral hydronephrosis, and streptococci were cultured in the urine obtained from the left kidney. He was well four years later except for occasional recurrence of the bleeding. The case was probably one of chronic streptococcal infection.

Case 6.—Man of 42, with symptomless hæmaturia; investigations negative. Doubtful occasional recurrence of the bleeding during the following year, otherwise he was well.

Case 7.—Woman, aged 38. Exploratory nephrotomy and nephropexy had been performed five years before she attended the department. She continued to complain of left renal pain and occasional hæmaturia. Investigations inconclusive; pyelogram normal. On inquiry another five years later (i.e., ten years after operation) she still suffered from renal pain and occasional hæmaturia but was otherwise well; urine offensive. Diagnosis: suggestive of secondary infection.

Case 8.—Woman, aged 54. Attended with painless hæmaturia as the presenting symptom; some frequency; blood-stained urine seen coming from left kidney on one occasion. Pyelogram normal. Attended for two years, with occasional bouts of slight hæmaturia (smoky urine); no bleeding for past year: otherwise well.

No Reply Received to Letters of Inquiry.—There were 17 cases (10 men and 7 women) in which the hæmaturia was not definitely explained. These patients could not be traced, so little benefit will result from a detailed consideration of them, but mention will be made of the probable diagnosis.

Ten men (average age 29 years): 1 probably cystitis; 1 probably varicose veins of bladder; 1 probably oxaluria; 3 probably pyelitis; 1 hæmaturia associated with extreme changes of temperature; 3 nothing abnormal found.

Seven women (average age 29 years): 2 probably cystitis; 1 probably *B. coli* infection; 1 probably varicose veins of bladder; 2 associated with renal colic; 1 probably rena mobilis.

Inquiry Made: Had Died.—There were 4 cases of unexplained hæmaturia (2 men and 2 women) who had died. Probably in only one case was the cause of death due to the trouble for which they attended hospital.

Case 1.—Man, aged 50. Hæmaturia perhaps due to slight prostatic enlargement. Remained perfectly well whilst he was kept under observation at hospital for fifteen months. Died of acute lung condition.

Case 2.—Man, aged 54. Symptomless hæmaturia. Nothing abnormal found except slight prostatic enlargement. Died of carcinoma of the prostate eight years later.

Case 3.—Woman, aged 38. Hæmaturia and frequency associated with pregnancy on two occasions. Died of pneumonia.

Case 4.—Woman, aged 64. Symptomless hæmaturia for four weeks. Investigations negative. Died of 'stroke' two years later.

DISCUSSION AND REVIEW OF THE LITERATURE.

The findings given in this paper appear to show that very few cases of hæmaturia are unsatisfactorily assessed in a modern urological department: though the actual cause of the bleeding was not always discovered, those cases which were unexplained did not suffer in consequence. Pure uric acid calculi which are not opaque to the X rays appeared to be a cause of missed diagnoses (these, however, can be shown up by pyelography, the stone appearing as a radio-translucent area around the opaque medium).

As stones may form around a nucleus of blood-clot, it may be that these calculi were not present when the patient attended hospital, but formed afterwards on a nucleus of blood-clot or fibrin which had not been voided.

The importance of hæmaturia as a symptom still needs to be stressed: all cases should be investigated and if possible explained. Too often patients attend hospital with a long-standing history of repeated attacks of bleeding; if pain is absent, both patient and doctor are often satisfied to await further developments rather than submit to an investigation in the early stages, when results of treatment are much more satisfactory.

The dangers of hæmaturia *per se* are slight; the loss of blood is rarely so severe as to endanger the patient's life, and it does not cause the profound collapse which is found with a severe hæmatemesis or hæmoptysis, though considerable anæmia, of course, results from persistent bleeding.

The symptom is a valuable one, for it immediately directs attention to the urinary tract, and is therefore of great diagnostic importance. About one-third of the patients attending the Genito-urinary Department gave histories of hæmaturia. Though it focuses attention on the urinary tract, the primary lesion is not necessarily situated there; one case seen recently first attended with hæmaturia which was subsequently explained by a subacute infective endocarditis. Not uncommonly the bleeding arises from a complication which has occurred as the result of a lesion in the urinary tract: for instance, it may be due to a vesical calculus complicating prostatic enlargement, or to cystitis following on a stricture of the urethra. In women supposed hæmaturia may in reality come from the genital tract, and this point occasionally needs attention.

It has been noticeable throughout this investigation that despite the fact that chronic inflammatory conditions are so much more common in women than in men, neoplasm is comparatively rare: this observation is at variance with the oft-repeated assertion that chronic inflammation predisposes to carcinoma, and it seems that we shall have to look elsewhere for the explanation of this phenomenon in the urinary tract.

During recent years Kretschmer,[1] of Chicago, has reported the most complete series of cases of hæmaturia. He reports 933 consecutive cases, 860 of which were diagnosed. The general similarity between the two series

is quite marked, the chief differences being that neoplastic conditions and tuberculosis are more common in Kretschmer's series, whereas other inflammatory conditions are less common.

Mackenzie[2] summarizes a series of 821 consecutive cases of hæmaturia which occurred amongst the 3800 patients who attended the Department of Urology at the Royal Victoria Hospital, Montreal. He finds that "excluding the urethra 536 cases out of 761, that is, over 70 per cent, were caused by calculi, tuberculosis, cancer, or surgical lesions of the kidney."

Van Duzen[3] reported a series of 500 cases; the source of the bleeding was: urethra 38 cases, prostate 59 cases, bladder 82 cases, ureter 75 cases, and kidney 172 cases.

Cases of unexplained hæmaturia occur at all ages and in both sexes. The hæmaturia is especially likely to be unexplained when it is the presenting symptom or the only symptom and when the case is seen after the bleeding has ceased. If nothing abnormal can be found on examination, the prognosis is good.

If the bleeding has been localized to one kidney, and nothing abnormal is found on thorough examination and repeated pyelograms are normal, conservative treatment should be adopted unless bleeding endangers the life of the patient or produces a grave anæmia. If exploratory nephrotomy is performed, most probably nothing abnormal will be found, and the surgeon may remove a normal kidney thinking that he is dealing with an early malignant neoplasm. Investigations indicate that this is most improbable.

The literature on essential hæmaturia must be referred to in connection with these unexplained cases. Various explanations of it have been given; Braasch[4] says: "I am under the impression that it would be difficult to assign any one cause to the variety of conditions which are grouped under the term essential hæmaturia", and the findings of this investigation support his view.

Some urologists believe that the diagnosis of essential hæmaturia serves as a cloak for ignorance of the exact condition, and think that the bleeding is in reality the early manifestation of some serious disease such as nephritis, carcinoma, or tuberculosis.

Bumpus[5] reviews 155 cases of essential hæmaturia five to twenty years after the diagnosis had been made at the Mayo Clinic: only 6 of these reported the development of any definite renal disease. In 3 calculi developed, and in 3 others nephrectomy was performed for unknown reasons (? for persistent bleeding): 21 had died, 105 patients were reported in good health, 44 in fair health, and 6 in poor health. He concludes that "we may dismiss the idea that the hæmaturia was caused by early malignant growth or any other serious disease in its incipency". Levy[6] came to a similar conclusion, and the same results are shown in this thesis.

The various conditions which are believed to be the cause of essential hæmaturia are well discussed by Bumpus. They may be summarized thus:—

1. *Nephritis.*—Bumpus found no confirmation of this explanation in the follow-up of his 155 cases; the present investigation corroborates his view.

2. *Chronic Passive Congestion.*—This has been suggested as a cause of the bleeding (Spitzer,[7] Rathbun[8]).

3. *Dilated Veins or Varix Papillæ.*—These, with or without associated inflammation, appear to be definite causes in some cases; so called papillitis or angioma of the papillæ.

4. *Infection.*—Focal infection may sometimes be responsible; septic tonsils or infected teeth are often found, and the removal of these appears to clear up a number of cases. Kidd[9] attaches much importance to the removal of septic foci in patients with purpura of the urinary tract.

5. *Blood Dyscrasia.*—This probably accounts for a few cases. Conner and Bumpus[10] paid particular attention to this theory in a study of 33 cases; they found little evidence that the disease was a localized purpura hæmorrhagica except for the low platelet-count, which averaged 136,000 for the group, about half the normal. They suggest that the deficiency in platelets may have a bearing in some cases. One case in the present series appears to be an example of a blood dyscrasia.

It seems that there are numerous causes of so-called essential hæmaturia; the lesion is a minor local lesion of the kidney of various kinds; indirect treatment is usually all that is required. Very occasionally if the bleeding is so severe as to endanger the patient's life, operation is indicated.

'Essential hæmaturia' is an unsatisfactory name, and it has been said should be used "only in the quietness of one's study, or with very intimate friends, but never to an intelligent patient." The time-honoured name of 'renal epistaxis' given by Sir William Gull, seems to be more satisfactory, and more accurate, since it does not lay unnecessary stress upon what is, after all, only a minor local lesion of the kidney.

SUMMARY OF CONCLUSIONS.

1. Papilloma and carcinoma of the bladder are the commonest causes of hæmaturia in men.

2. Inflammatory conditions of the urinary tract are the commonest causes of hæmaturia in women.

3. Hæmaturia as a presenting symptom: In men there is a 50 per cent chance that it is due to a papilloma or carcinoma of the bladder. In women the cause is as likely to be inflammatory as neoplastic.

4. Hæmaturia as an only symptom (65 cases): In men there is a two to one chance that it is due to papilloma or carcinoma of the bladder. In women (10 cases) the commonest cause was renal calculus.

5. Over the age of 50 the prostate is a common cause of hæmaturia in men.

6. In 130 cases of hæmaturia in men over 60 years, 43 per cent were suffering from papilloma or carcinoma of the bladder, and 37 per cent from simple or malignant enlargement of the prostate.

7. Cases of carcinoma of the bladder are not infrequently associated with prostatic enlargement; the symptoms are in some cases rather similar; unless cystoscopy is performed a case may for a time be considered to be one of prostatic enlargement and so valuable time be lost.

8. The common causes of hæmaturia in the different decades of life are shown on a graph. The conclusion is that hæmaturia is rare in the first two

decades. In the second and third decades inflammatory conditions and calculi are the commonest causes in both sexes. Neoplasm becomes the commonest cause of hæmaturia in men in the fifth decade of life, and in both sexes in the sixth decade of life.

9. Carcinoma of the kidney is rare; it was the cause of only 2½ per cent of all the cases of hæmaturia (men 3 per cent, women less than ½ per cent).

10. Renal calculi not uncommonly cause hæmaturia which may be almost or quite painless.

11. The diagnosis of hæmaturia due to varicose vesical veins must be made with very great caution, unless the bleeding is actually seen to be coming from a varix.

12. Cases of moderate and well-marked hæmaturia should be cystoscoped during the attack of bleeding.

13. Cases suggestive of carcinoma vesicæ with very foul urine containing much blood are usually cystoscoped more satisfactorily after rest in bed for a few days and treatment to the bladder, otherwise nothing can be seen through the dirty medium.

14. Of the 66 cases of unexplained hæmaturia 49 were traced, and the after-history discovered, and of these :—

Four cases (8 per cent) reported that calculi had been either passed or removed.

Thirty-three (67 per cent) were almost or quite well, no more bleeding having occurred.

Eight (16 per cent) reported recurrence of bleeding on one or more occasions. All were well or only slightly inconvenienced, except one man who had syphilis and had become blind.

Four (8 per cent) had died, two of acute lung conditions quite unconnected with the hæmaturia, one of carcinoma of the prostate eight years after his attendance at hospital, and one of stroke.

The most difficult cases to diagnose are those giving few symptoms other than the hæmaturia which has ceased by the time the patient attends hospital. Cases of unexplained hæmaturia fall into several different categories; the prognosis is good if nothing abnormal can be found on full urological investigation.

I am greatly indebted to Mr. Hugh Lett both for permission to investigate these cases and for his kind advice; also to Dr. Joules for helpful criticism.

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A CASE OF RENAL AND URETERIC CALCULI OF UNUSUAL SIZE. REPEATED FORMATION OF CALCULI.

By EDGAR FRESHMAN,

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The following case is an interesting example of 'continuous' stone formation in the urinary tract, and illustrates the enormous size that may be obtained by calculi before giving rise to symptoms severe enough to induce the patient to seek relief:—

First Admission.—A man of 22, by occupation a clerk, was admitted to the London Hospital in June, 1923, in a typical attack of left renal colic, which lasted for about twelve hours. He had had no previous attacks, but gave a history of having had hæmaturia on two occasions during the past twelve months. The urine contained pus and blood. Two days later he had a sudden stoppage of the flow during micturition, accompanied by severe pain in the penis. A tender mass was palpable in the urethra, one inch from the external meatus, and an attempt at catheterization confirmed the presence of a calculus. An anæsthetic was administered for the purpose of urethroscopy and removal of the calculus, but this was at once passed, in front of a stream of urine; it was the size and shape of a date-stone.

Six days later another stone became impacted at the same spot, again causing acute retention of urine. The patient was anæsthetized, and again the retention was relieved by the immediate passage of the calculus, which was about half the size of the first one.

X-ray examination revealed a group of shadows towards the lower pole of the left kidney; the right kidney was clear. On July 12, 1923, the left kidney was explored; a moderate hydronephrosis was found, most marked towards the lower pole, and a number of small stones were removed. The renal pelvis was drained through an incision in the cortex. A urinary fistula persisted, and on exploration a little pus was evacuated from the kidney, and the ureter proved to be patent and unobstructed throughout its length. The fistula healed rapidly, and the patient was discharged as fit on August 25, 1923.

Second Admission.—In November of the same year he was re-admitted. He stated that for two months he had had pain in the perineum and at the tip of the penis at the end of micturition, and momentary painful stoppage of the stream in the middle of the act. He had had no hæmaturia, but his urine had been 'brick-red with gravel'. He was always most comfortable when the bladder was full. Radiography revealed one vesical and one renal calculus, this time on the right side, lying in the body of the kidney. After a confirmatory cystoscopy, the vesical calculus was crushed and removed, with a view to subsequent removal of the one in the kidney.

A few days later the patient had an attack of right renal colic—the first caused by the hitherto 'quiescent' right renal stone, and a further X-ray examination showed that it had moved into the pelvis of the kidney. A right nephrotomy was performed, and a calcium carbonate stone, 2·5 cm. long and 1·5 cm. broad, was removed from the moderately dilated pelvis, and a smaller one, whose shadow had evidently been hidden by that of the larger, from a dilated major calyx. The kidney was drained, and the patient was discharged five weeks later.

THIRD ADMISSION.—The urine remained rather dirty, but he was free from symptoms until a short time previous to his re-admission to hospital in August, 1924, on account of his having had several further attacks of right renal colic during the preceding few weeks, the last one culminating in the passage of a small calculus the day before admission. Two calculi, the larger 2·5 cm. in diameter, were seen in the *left* kidney on X-ray examination, the right side being clear. Chromo-cystoscopy showed depressed function of the left kidney, that of the right being normal. There was no pus in the ureteric catheter specimen of urine from either side; a culture of that from the left side gave a growth of *B. proteus*, but nothing from the right. A left nephrotomy was again performed, through as small an incision as possible, and two calcium carbonate stones were removed from the renal pelvis. The kidney was drained, and the patient discharged with a soundly healed wound two and a half weeks later.

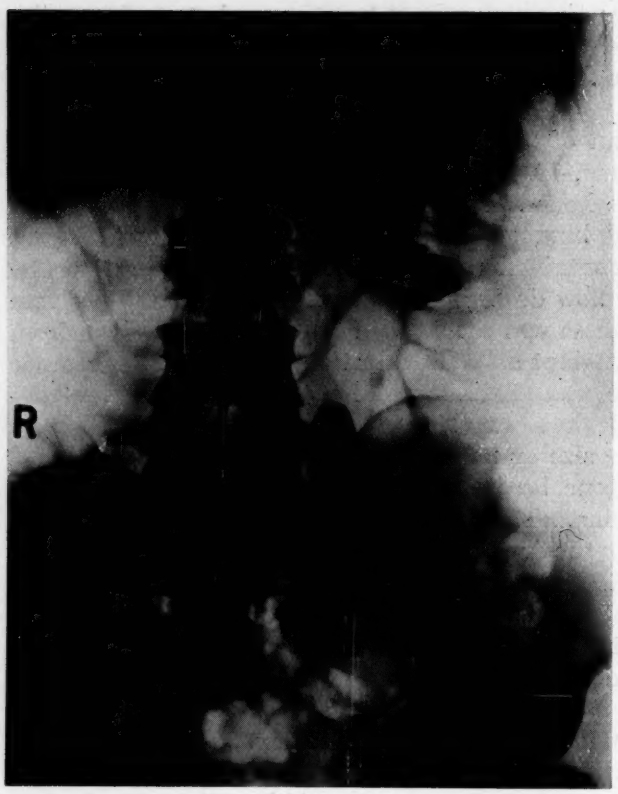

FIG. 43.—Radiograph showing renal and ureteric calculi.

He did not report again until March, 1932. He had remained perfectly well until about the middle of 1930, when he began to get attacks of aching pain in the left lumbar region, which 'passed through from back to front', but never radiated towards the groin. There were long intervals of freedom between the attacks, which invariably occurred at the end of a heavy day, and were relieved by rest, hot drinks, and hot packs. There were no other symptoms, and the urine had remained clear until November, 1931, when there was an attack of hæmaturia. Another followed in three weeks, and a

fortnight later the patient had an acute attack of left renal pain, with no radiation. The radiograph (*Fig.* 43) showed an enormous beaked and branched calculus lying in the upper part of the left kidney, with its beak in the pelvis, and two irregular stones lying below it. The left ureter contained a huge rod-shaped calculus in its middle third, and a three-sided one opposite the ischial spine. The right kidney and ureter appeared clear.

Fourth Admission.—The patient was re-admitted to hospital in April, 1932. The total urinary function was satisfactory (blood-urea 0·025 per

Fig. 44.—Calculi removed at operation. A, Renal; B, Ureteric.

cent; urea concentration 1·98 per cent, and 2·26 per cent), and the urine contained no pus. Cystoscopy showed small calculous débris lying on the trigone, especially near the left ureteric orifice, which was almost closed, and had somewhat irregular and rigid-looking margins. Its contractions were infrequent and spasmodic. Intravenous injection of indigo-carmine produced dye from the right side in five minutes, and none from the left in fifteen.

On April 5, 1932, left uretero-nephrectomy was performed. Under the anæsthetic, the large ureteric calculus was easily palpable through the abdominal wall. A gridiron incision was made in the left iliac fossa, and the left ureter exposed by stripping inwards the peritoneum, to which it was

extremely adherent. The smaller calculus was milked upwards, the ureter divided below it, a little below the level of the pelvic brim, and separated upwards as far as possible. The usual oblique kidney incision was then made in the loin, where the abdominal wall was largely replaced by scar tissue, to which the kidney was firmly adherent, with the result that the incision opened directly into a calix, liberating thin purulent urine. This incision was enlarged, and the three calculi were removed. The kidney was a mere shell of fibro-fatty tissue, very adherent to the peritoneum and splenic flexure; the ureter was rigid and fibrous and was firmly adherent to the peritoneum. The kidney and practically the whole of the ureter with its contained calculi were removed in one piece with considerable difficulty. The wound healed satisfactorily, and the patient was discharged eighteen days later.

Fig. 44 depicts the calculi removed at the last operation. As is seen in the radiograph, the large renal stone lay with its long beak in the pelvis and its branching body in the upper calices. The composition of all five was the same—namely, calcium and magnesium phosphate, with traces of calcium oxalate and carbonate. The measurements of the two largest were as follows:—

Renal calculus ..	Maximum length	7·2 cm.	Weight 1·45 oz.
	,, breadth	5·5 ,,	
	,, thickness	3·2 ,,	
Ureteric calculus ..	Length	7·6 cm.	Weight 0·86 oz.
	Maximum diameter	2·0 ,,	

Now, fifteen months after his last operation, the patient is in excellent health, and on X-ray examination his right kidney appears to be free of stones. Intravenous pyelography shows good excretion in five minutes, and an almost normally shaped pelvis and calices.

COMMENTARY.

The patient thus underwent six operations; on seven occasions he was relieved of a calculus or calculi under general anæsthesia, and one he voided spontaneously.

The rate at which he formed stones is worthy of note. All calculi then visible on X-ray examination were passed per urethram or removed from the left kidney in July, 1923. Four months later he was found to have two in the opposite kidney, and one in the bladder. Ten months after this, another, which according to the symptoms had also come from the right side, was passed, and two more were removed from the pelvis of the left kidney—i.e., fourteen months after nephro-lithotomy had been performed on that side. An interval of nearly six years elapsed before the onset of symptoms suggesting the presence of further calculi. None of the stones had a core of pure uric acid, which might have accounted for their existence some time before becoming opaque to X rays.

I am greatly indebted to Mr. Hugh Lett, under whose care the patient has been since he first attended hospital, for his kind permission to publish these notes on the case, and also to Dr. Vilvandré for allowing me to reproduce the radiograph.

OSTEO-CHONDRITIS DISSECANS.*

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Osteo-chondritis dissecans may be defined as a condition in which a fragment of articular cartilage and subchondral bone becomes separated, partially or completely, from typical positions at the ends of certain of the long bones.

The term 'osteo-chondritis dissecans' is retained purely for convenience, since I believe it has come to mean to the surgeon a definite pathological condition, though, as I shall hope to prove, the name is hardly justified by the etiology. Though usually found at definite sites of election in the joints affected, the typical lesions are occasionally seen elsewhere on the articular surfaces. It is characteristic, however, of this affection that the lesions, with few exceptions, are found in the deeper parts of a joint, where direct damage from external violence is least likely to occur. It is usually said that males are far more commonly affected than females. Phemister,[1] for instance, gives the proportion as 13 to 1, but this has not been our experience. In a small personal series of 20 cases affecting the knee-joint, the sexes were equally divided. The patients are usually adolescents or young adults, in perfect health, vigorous, and indulging in the usual strenuous pastimes of their age. The youngest patient on whom I have operated for a typical lesion in the knee-joint was a girl of 9 (*see Figs.* 48, 49.) Phemister reports a case in a girl of 12.

Trauma is a common and marked etiological factor, but a history of it is by no means always obtained. The joint most commonly affected is the knee, but similar lesions have been described in the elbow-, ankle-, and hip-joints, and even in a metatarsal head (Richards[2]). Bilateral lesions have been reported by several writers. I am indebted to Mr. Rowley Bristow for slides of bilateral lesions in the knees of a boy, with symptoms only in one. Operation on the painful knee revealed an area of cartilage outlined by a thin yellow line, along part of which an incision was made. As the fragment of bone beneath was firm, nothing more was done. Two months later there were no signs of disability in the joint. Somner reports a case with both knees and one elbow affected.

The typical situations for the lesions in the various joints are as follows: in the knee, the inner condyle, close to the intercondylar notch; in the elbow, the capitellum; in the ankle, the trochlear surface of the astragalus; in the hip, the highest point of the femoral head. Cases with the external condyle

* An abstract of this paper was read at the Centenary Meeting of the British Medical Association (Orthopædic Section).

of the femur affected have been reported by Balensweig,[3] Delchef,[4] and Heine,[5] and bilateral lesions of this condyle by Niessen.[6] We have met with lesions of the external condyle and also of the patella. If the fragment is not displaced, the symptoms are those of a chronic joint trouble of mild character, such as vague discomfort with persistent or recurrent fluid—both aggravated by violent exercise—weakness, loss of confidence in the joint, and so on.

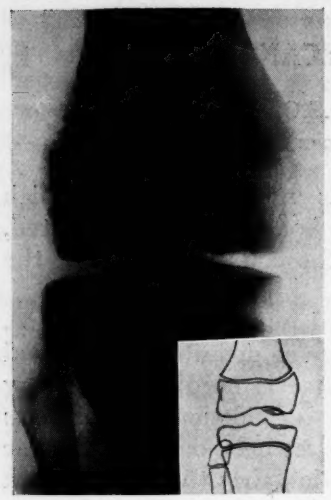
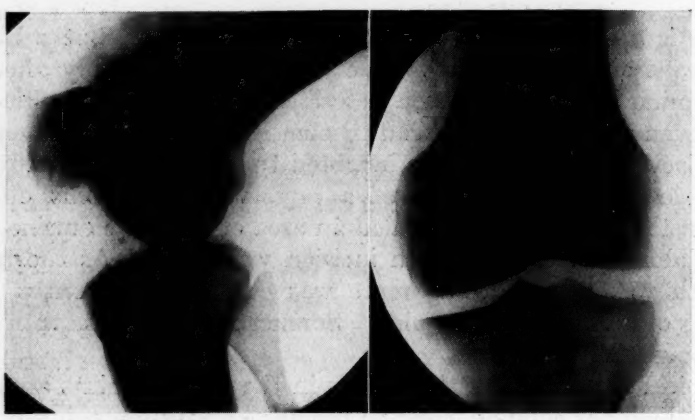


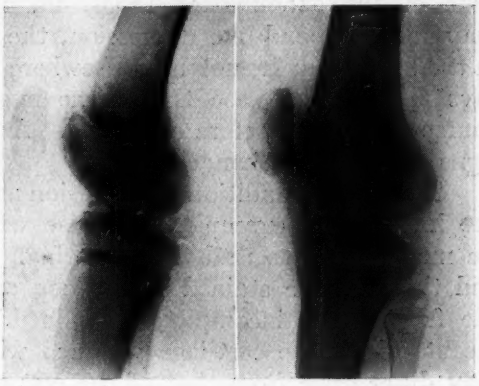
FIG. 45.—Radiogram showing typical lesion in knee-joint. Boy, aged 14. Cut foot: laid up two weeks. On walking again noticed knee bent and swollen. Pain on extension.

On examination of the *knee*, for instance, nothing may be found but the signs of fluid and wasting of the quadriceps, and possibly some limitation of movement. Hellström[7] says pain on extension is common. The only special sign, first described by Axhausen,[8] I believe, and certainly present in some cases, is tenderness on deep pressure over the site of the lesion when the knee is flexed. If the fragment has become completely displaced, the symptoms will be those of a loose body. Symptoms may, however, be absent, as, for instance, in a bilateral case discovered by routine X-ray examination for symptoms confined to one knee. The radiographic picture is characteristic and determines the diagnosis. In the lateral portion of the inner condyle is seen a fragment, apparently loose and lying in a depression of appropriate size and shape (*Fig.* 45). As a rule the fragment is single, but it may be multiple—a nest of two or three pieces (Jansson[9]) (*Figs.* 46, 47).

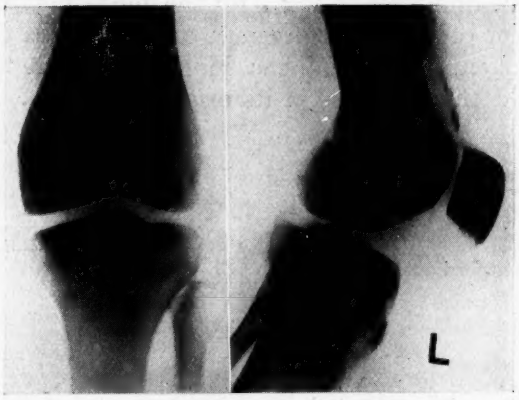


FIGS. 46, 47.—Multiple fragments—'nest of pieces'—lying in depression seen at typical site on inner condyle. Male, aged 27. Blow on knee five weeks previously. Severe swelling.

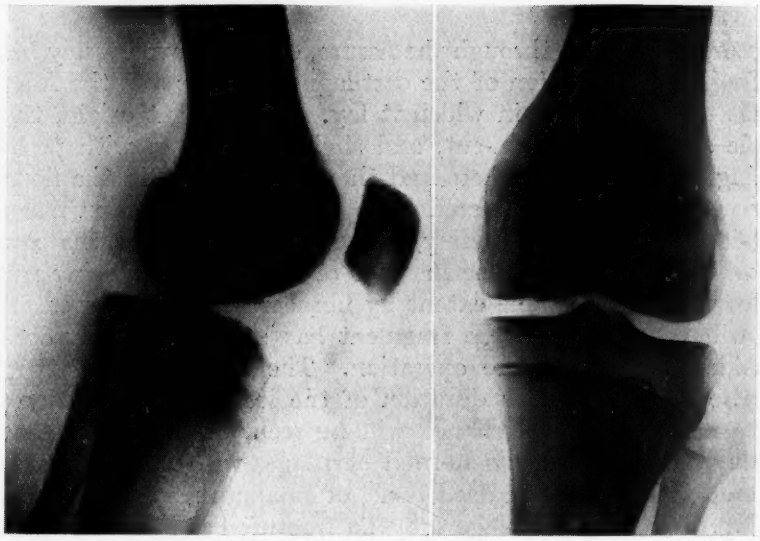
It may lie snugly in its bed, being marked off by a clear line from the rest of the bone, or it may appear to be hanging by a hinge, the amount of displacement in some cases varying with the position of the joint at the



FIGS. 48, 49.—Skiagram showing replacement of hinged fragment by full extension of joint. Girl, aged 9. Six months' history of pain and swelling. No definite trauma.



FIGS. 50, 51.—Skiagram showing crater in inner condyle and completely detached fragment in suprapatellar pouch. Operation confirmed the above. Male, aged 19. Footballer, but no definite injury. Swelling for three months before knee became locked momentarily.



FIGS. 52, 53.—Knee showing typical lesion with partial detachment of fragment. Boy, aged 16. Long history with several injuries.

time of the examination (*Figs.* 48, 49). On the other hand, the condyle may show a pond-like depression, the fragment, completely displaced, lying in the intercondylar notch or elsewhere in the joint (*Figs.* 50, 51). Frieburg[10] says that in one case the 'dense nucleus' increased greatly in size in the course of a year before operation. At this stage there are usually no X-ray signs of arthritic changes.

The actual condition of the lesion as revealed at operation varies. Taking the knee as an example, in a case with a typical radiogram (*Figs.* 52, 53) we may expect to find the following. Fluid in excess is commonly present, and this may be stained with blood or altered blood-pigment. The site of the fragment is incompletely outlined by a fissure in the cartilage. If of recent origin, the cartilage included within the circumference of this fissure may differ little from that of the rest of the articular surface, but it is often somewhat opaque, having lost the normal transparent bluish appearance, while it may be roughened, sodden, and even stained by the blood-pigment in the synovial fluid. At one aspect of the circumference, often towards the mesial side, the cartilage is unbroken, here forming a hinge by which the osteo-cartilaginous fragment is held more or less in its original position. A

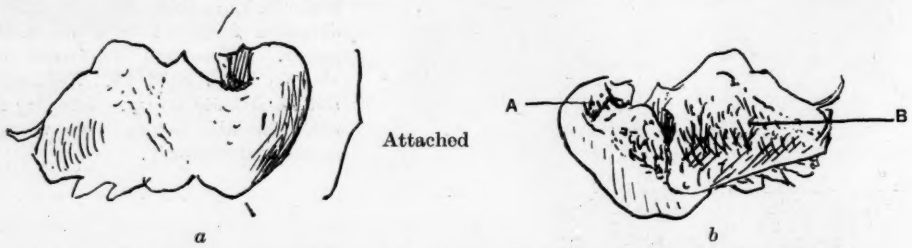
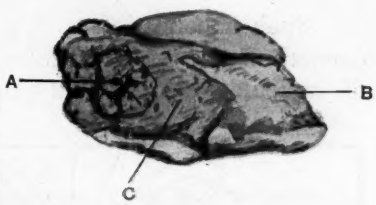


FIG. 54.—Fragment of cartilage, calcified cartilage (B), and bone (A) removed from knee seen in *Figs.* 52, 53, showing shaggy irregular margins. In spite of a long history the detachment appears to have been recent. *a*, Superficial surface. *b*, Deep surface. (*Actual size.*)

flat dissector, introduced through the fissure, can be moved freely beneath the loosened fragment. Division of the cartilaginous hinge sets the fragment free and reveals the depression in which it lay. If of recent origin, the margins of this hole are abrupt, clean-cut, and slightly shelving, with perhaps some undermining of the cartilage here and there. The bone in the floor presents a slightly concave surface covered by a thin layer of sodden fibrous tissue. If the lesion is of long standing, some proliferation of the surrounding cartilage will have occurred, the margins of the hole then being rounded off and the floor invaded to some extent by fibrocartilage. The greatest amount of repair will be seen when the fragment has been completely detached for some considerable time before operation. The appearance of the fragment removed also varies with the duration of the lesion. If operation has been resorted to early, but little change will be seen, the fragment consisting of a convex layer of more or less normal cartilage, with slightly frayed abrupt margins, and with a piece of dead bone, of smaller area, adherent to its deep surface (*Fig.* 54). The cartilage may be fractured across the middle of the fragment. If sufficient time has elapsed, the margins of the fragment will be rounded off, and the bone on its deep aspect may be partially covered as

a result of proliferation of the overlying cartilage (*Fig.* 55). These changes are particularly well seen when the detached fragment includes a portion of the intercondylar notch and is anchored by a pedicle of synovial membrane in which may be present a few fibres of the posterior crucial ligament. In this case the bone in the fragment is living and may show evidence, under the microscope, of new bone formation.

FIG. 55.—Fragment of cartilage and bone removed, four months after injury to foot, from knee shown in *Fig.* 45. Fragment partially loose and stained with blood-pigment. The margins have become somewhat rounded off. A, Bone; B, Cartilage; C, Fibrous tissue. (*Actual size.*)



Such are the common findings. There are others, however, which are less frequently met with. In spite of the typical radiogram the cartilage may be found unbroken, as in Mr. Bristow's case. The site of the lesion may still be obvious, however, the cartilage being discoloured, roughened, sodden, and outlined by a line or slight groove. Though the surface is unbroken, this portion of cartilage may be slightly but quite definitely mobile over the underlying bone. On incising around such an area, the fragment, including some bone, may be found completely undermined and loose, as reported by Richards, Frieburg, and Ludloff.[11] On the other hand, in spite of a typical radiogram, incision of the unbroken cartilage may reveal no loose fragment. In our series a femoral case of this type required the slight use of a gouge to complete the separation of the bony fragment (*see Figs.* 45, 55), while in a lesion of the patella, on the other hand, there was no suggestion of the bone being loose (*Fig.* 56). Where the fragment includes the condylar margin and has become completely detached, one occasionally sees the resulting crater occupied by a polypoid growth from the soft tissues in the intercondylar notch. As is sometimes seen after traumatic lesions of the articular margin elsewhere in the joint, this polyp may be fibrocartilaginous in consistence. It is not very uncommon, however, to see lesions of the articular cartilage only in the typical situation on the inner condyle, when, for one reason or another, a knee-joint with a normal X-ray is explored. The cartilage may be simply roughened or pitted; its surface may be soft and sodden; over a limited area it may be movable on the underlying bone; a thin flake

FIG. 56.—Lateral skiagram of knee showing fragment, apparently loose, lying in crater in patella. At operation fragment found quite firm. Girl, aged 14.

not involving the whole thickness of the cartilage may be raised and hanging by a hinge; or, lastly, a fragment of cartilage may be completely detached from the typical site, leaving a sharp-edged crater with a *convex* floor formed by the undamaged bone of the condyle.

a *b*

FIG. 57.—Free fragment of normal cartilage only, with abrupt recently fractured margins, removed from intercondylar notch. Woman, aged 24. Five years' history of trouble in knee. Recent injury. Knee locked. Released under gas. *a*, Superficial surface. *b*, Deep surface. (*Actual size.*)

Such a condition as the last was revealed in a young woman who was carried off the tennis court with a locked knee. Two weeks later a free flake of articular cartilage, apparently recently detached and showing abrupt margins, was removed from the intercondylar notch (*Fig.* 57). The X-ray was negative, but at the operation the crater from which this flake had been detached was seen on the inner condyle at the usual spot. The joint contained dark blood. There was a history of the knee having been twisted while skiing five years before, with some trouble on four occasions since. In spite of this history, the evidence pointed strongly to the lesion being the direct result of the recent trauma.

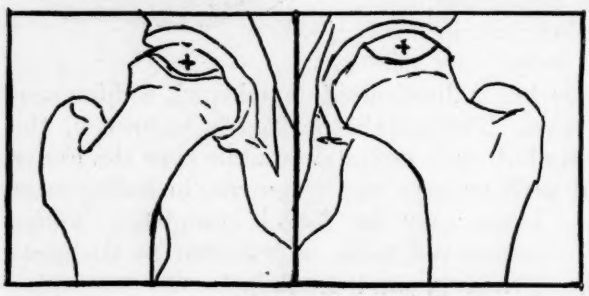


FIG. 58.—Bilateral osteo-chondritis dissecans of head of femur. (*After Lange.*)

In the *elbow*, after trauma, we are all familiar with obvious and varying X-ray changes in the capitellum, short of complete displacement of this bony prominence. A study of the elbow cases is complicated by the occurrence of what is believed to be a non-dissecting type of osteo-chondritis of the capitellum, and I do not propose in this paper to embark on a consideration of the difficult problem presented by this joint.

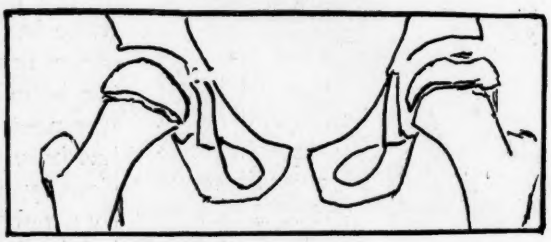


FIG. 59.—Unilateral osteo-chondritis dissecans of head of femur. (*After Gold.*)

Osteo-chondritis dissecans of the *hip-joint*, of which I have no personal experience, seems to be on the same plane as the elbow. The lesions said to be typical in this joint are well seen in the radiograms of a bilateral and a unilateral case published by Lange[12] and Gold [13] respectively (*Figs.* 58, 59).

They should be compared, however, with the very suggestive appearances seen in the head of the right femur in the radiogram of a boy of 6 (*Fig.* 60). This small lesion did not progress, but cleared up in the course of a few

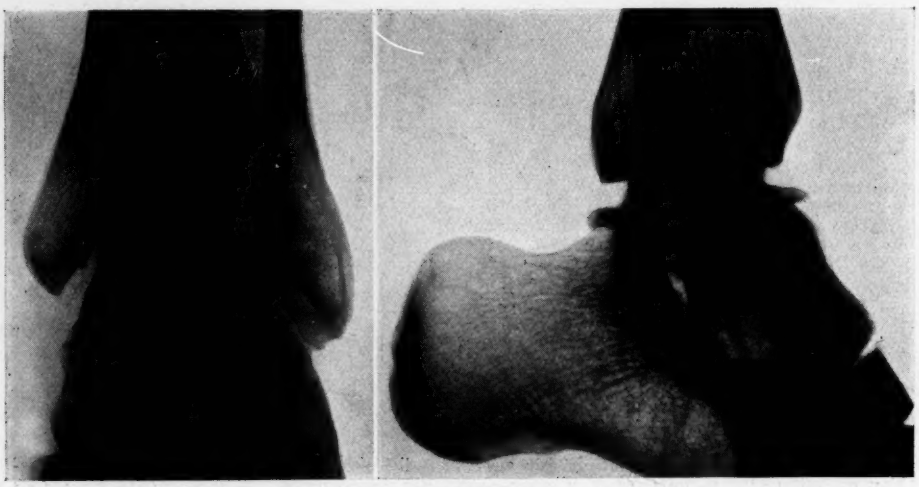
FIG. 60.—Boy, aged 6. Right hip shows small lesion at highest point of head suggestive of lesion said to be typical of osteo-chondritis dissecans of hip-joint. Left hip shows typical pseudo-coxalgia.

months. The other hip progressed through all the changes typical of pseudo-coxalgia. This second case seems to show a similar contrast in the X-ray shadows thrown by the two hips (*Fig.* 61).

FIG. 61.—Boy, aged 7. Right hip shows lesion in head of femur similar to osteo-chondritis dissecans. Left hip shows early change of pseudo-coxalgia.

A lesion of the type under discussion affecting the *ankle-joint* I have met with only once, and then in a young woman, kindly referred to me by Mr. Tyrrell Gray (*Figs.* 62—64). There was a definite history of trauma.

Exploration revealed a typical clean-cut osteo-cartilaginous fragment partially detached from the saddle surface of the astragalus, and only held in place by a cartilaginous hinge behind.



FIGS, 62, 63.—Osteo-chondritis dissecans of astragalus. Young woman, with history of trauma. Note fragment partially detached from superior articular surface of astragalus.

a *b*

FIG. 64.—Fragment removed from case shown in *Figs.* 62, 63. *a*, Superficial surface. *b*, Deep surface. (*Actual size.*)

Though several writers mention the *shoulder*, I have not found any detailed reference to a typical lesion of this joint.

ETIOLOGY.

Though Broca,[14] Teale,[15] and Paget[16] had previously and independently suggested that the separation was effected by a pathological process—a 'quiet necrosis'—following trauma, König's[17] name is usually associated with this theory. He gave to the condition the name by which it is generally known to-day, but admitted that all signs of inflammation had disappeared. The majority of surgeons accept trauma as playing some part at any rate in the etiology, if only as the cause of the final complete displacement of the fragment. It will be as well, therefore, to consider first how trauma can possibly occur at the typical spot on the inner condyle. Direct injury from without can be ruled out, since at the site of election for these lesions the articular surface is well protected in all positions of the joint. The blow or blows must be struck by one of the other two bones forming the joint. Two theories receive support: first, that the patella is responsible, and second, the tibial spine.

Now the patella normally comes in contact with this particular portion of the inner condyle only when the joint is fully flexed, and this is surely a very unusual position for the knee when the latter is traumatized. It seems quite out of the question that the patella could damage the inner condyle at the site of election without the assistance of external violence, and then only if the joint were flexed beyond a right angle. Then again, if the patella is commonly responsible, one would have expected the flexed position of the joint to be mentioned in the histories of some of the cases at any rate. Brackett,[18] it is true, cites a case of the typical lesion resulting from a severe blow on a fully flexed knee, and calls attention to the fact that many of his patients followed occupations involving an excessive amount of kneeling, but this does not seem to be the experience of most writers. Hellström, however, also blames the patella, believing the lesion to be an incomplete fracture resulting from repeated minor traumata, the damage occurring when the joint is flexed.

Professor Blair, to whom I am much indebted for helpful criticisms, made the interesting suggestion that, since kneeling puts tension on the posterior crucial, excessive kneeling might induce an abnormal development of the inner tubercle of the tibial spine—to which this ligament may be partially attached—and thus indirectly favour the occurrence of the lesion. As regards the patella itself, in several of our cases (7 of 20), the deep surface has shown signs of damage. The cartilage has been split, pitted, shredded, and sodden, but not as a rule at its inner margin. These changes are not, however, invariably present, and are seen quite commonly without a condylar lesion ; I have always regarded them as either secondary to the irregularity of the surface of the condyle or as independent traumatic lesions. Though admitting, of course, that a subluxating patella can damage the outer condyle, I think it extremely improbable that this bone is responsible for the lesions on the inner, except in very rare cases such as Brackett's.

It seems to me easier to accept the theory that the tibial spine is responsible. The inner appears to be the larger of the two tubercles in most knees, if not in all, but certainly in those affected by osteo-chondritis dissecans. Several writers have called attention to what they regard as the excessive size of the inner tubercle in their cases. There are two ways in which this tubercle may be forced against the inner condyle—namely, by rotation of the tibia on the femur (or vice versa) or by an external shearing force driving the tibia inwards or the femur outwards. It is difficult to obtain a clear account of the accident in cases with a definite history of trauma, but it seems probable that in most cases at any rate, the first suggestion, that of rotation, is correct. Roesner[19] favours the rotation theory, but speaks of the involuntary rotation, i.e., *external* rotation, which takes place just before extension is completed. In the cadaver he was able to produce lesions of the articular cartilage at the typical site by forced external rotation of the tibia.

In the hope of throwing light on this question, a number of dissected specimens were examined with Professor Blair. We found that as a rule impingement of the tibial spine against the inner condyle was produced by *internal* rotation of the tibia on the femur. Only in one of the specimens

examined was it evident that external rather than internal rotation of the tibia brought the spine to bear against the condyle.

Study of the lateral radiograms of affected knees suggests that the amount of flexion present at the moment of rotation must be very small. Frieburg says it is easy to make the spine impinge on the posterior crucial ligament, even when the inner tubercle is not unduly long. Barth,[20] who favours the pure traumatic theory, suggests that the pull of this ligament is responsible, but this could hardly explain the numerous cases in which the margin of the intercondylar notch is not involved in the lesion.

Now let us pass to a consideration of the various theories that have been suggested to explain the occurrence of the lesions.

Trauma Pure and Simple.—This means the lesion is a fracture. This theory receives the support of several writers, though they do not all agree as to the mechanism by which the injury occurs (Brackett, Richards, Barth, Roesner, and Kappis[21]). Since the evidence, it seems to me, is overwhelming that this theory is correct, it will be convenient to deal with the other theories first.

Trauma Followed by some Pathological Process.—We have already noted that the early writers thought the separation was the result of an inflammatory process set up by trauma—a 'quiet necrosis'. Unfortunately there is no evidence whatever of inflammation, present or past. The vast majority of investigators agree on this point. Mouchet and Bruas[22] speak of a 'diaclasic action' following trauma, by which they probably mean very much the same thing. The only alternative is that the blood-supply to a portion of bone is destroyed, directly or indirectly, by a trauma, and the resulting dead fragment is separated in the usual way, possibly with the help of additional traumata, but at any rate with a minimum of inflammatory reaction. If the vessels are severed by a crack in the bone, i.e., the fragment is broken off, as I believe it is, there is no need to invoke any obscure process to explain the death of the bone and its separation. Is it possible that the bone at the site of the lesion, though not actually fractured, is so bruised or otherwise damaged that necrosis occurs, without the addition of infection? This seems most improbable.

Somner[23] suggests that trauma, perhaps slight and oft-repeated, causes paralysis of the local vessels. Roesner found 'crushed trabeculæ', but this would agree with the pure traumatic theory better than with any other. Ludloff and Frieburg attribute the lesion to 'infarction' resulting from damage to the vessels entering the bone from the intercondylar notch. The former calls attention to a vessel, the arteria genu media, the branches of which ramify over the posterior crucial and the inner condyle, and which, he says, is often a terminal artery. If injury to this vessel were really the cause, one would expect to find the margin of the intercondylar notch included in the fragment with some regularity, whereas we know that this only occurs occasionally. Moreover, Nussbaum[24] affirms that this vessel is not an end artery. An even more convincing argument against this theory, as Phemister points out, lies in the fact that when the fragment includes the margin of the condy and is pedunculated by the crucial ligament and synovial membrane, the bone in the fragment is not dead but living, and may show evidence of new

bone formation. How can this fact be reconciled with any theory which presumes necrosis of the fragment before its separation? If the fragment is a sequestrum, cast off in the usual manner, where is the granulation tissue essential for this process? Though some describe the floor of the crater as being covered with granulations, I venture to assert that it is quite exceptional to find the cavity lined by tissue which could in any way justify this description. Even when the history and the condition of the margins of the fragment and crater indicate a recent separation, the latter is covered by nothing but the thinnest layer of fibrous tissue. Occasionally this tissue may be rather thicker and more vascular in places, but very rarely, in my experience, does it deserve the name of granulation tissue. Axhausen,[25] however, when operating soon after an injury found indications of a process long antedating the final trauma. He found resorption, very active connective tissue, and giant cells, eroding necrotic bone. König, as already stated, found no sign of inflammation. Hellström and Phemister both say the same. Paitre and de Bourguet[26] say that inflammatory exudate and cells are never found. Somner found no sign of inflammation in any of his twelve cases.

Wolbach and Allison's[27] post-mortem specimen, which they reported so carefully, was unfortunately complicated by a cyst in the condyle adjacent to the typical lesion, and was, therefore, quite exceptional. Any changes found in the thin layer of bone between the crater and cyst in their case are, I contend, useless so far as our discussion is concerned. They found the floor of the crater, however, covered with the usual layer of fibrous tissue with some cartilage cells. They remark on the absence of repair such as is seen in experimental incision of a bone or in a fracture; but are not the above signs of repair, and all that were to be expected on a surface bathed by synovial fluid and probably traumatized frequently by the fragment, which in their case was pedunculated? Opportunities such as this for complete examination of a crater and the bone beneath it must be extremely rare. On the other hand, for investigation of the loosened fragment there is an abundance of material. Microscopic examination of these fragments or loose bodies, it seems to me, shows only those changes which are known to occur in any osteo-cartilaginous fragment separated from an articular surface by direct trauma. If the blood-supply has been entirely severed, the fragment being loose or only held in place by a portion of unbroken cartilage, the bone is dead, though otherwise normal, while the cartilage is living and may show signs of proliferation. If a vascular pedicle was present, the bone as well as the cartilage may be alive, and if sufficient time has elapsed, there may be evidence of newly-formed calcified tissue and bone. If a subsequent trauma has completed the separation, the bone, though modified as above, will be dead. I have failed to find any report of findings which are not consistent with the separation having been effected by trauma, and trauma alone.

The Embolic Theory.—Axhausen,[28] who at first was a strong advocate of the 'damage-to-vessels' theory, is responsible for another suggestion which has received a fair measure of support, and which attributes the lesions to embolic infarction. He suggests attenuated tubercle bacilli as producing the occlusion of the vessels, but why such emboli, of tubercle or any other bacilli, should be found in healthy young people it is difficult to conceive. No proof

is forthcoming that such embolism occurs in these cases. If such is possible, why should the inner condyle be selected, occasionally even in both knees, and the usual sites in a bone for acute or chronic infection escape? Paitre and de Bourguet, supporting this theory, invoke a 'special fragility' of the epiphysis. Rieger[29] suggested fat embolism, and even stated he had found actual evidence of this, but no one has confirmed his improbable findings. The fact that when pedunculated the fragment consists of *living* bone and cartilage affords as strong an argument against this theory as it does against all the others with the exception of pure trauma. In this connection it is of interest to recall the experiments of Phemister, who killed portions of bone by insertion of radium into joints, and found that the necrotic fragments were not exfoliated, and moreover they gave rise to no inflammatory reactions, such as might have been expected, in the adjacent living bone.

Other Theories.—Bernstein[30] cites a bilateral knee case, a boy, with two sisters suffering from a similar lesion in one knee, and suggests an hereditary constitutional influence. Wagoner and Cohn,[31] of whose five cases three were members of the same family, also stress the hereditary factor. Weil[32], in view of the bilateral cases, speaks of it as a generalized disease.

Is it not at least as easy to assume, in these knees, an anatomical peculiarity present in all of them and favouring trauma at the typical site for these lesions? Archer and Peterson[33] suggest it is an adolescent affection similar to Perthes' disease, while Axhausen also draws a comparison between this condition and the familiar forms of osteo-chondritis. I have already admitted the difficulty of differentiating lesions of one type of osteo-chondritis from those of another in the elbow- and hip-joints. But the typical lesions in these joints, and also in the knee, are occasionally seen in cases long past the age for other forms of osteo-chondritis. My oldest knee case was 45, while two others, in one of which the fragment contained cartilage only, were over 40.

FIG. 65.—Lateral skiagram showing large fragment broken from posterior part of outer condyle, result of twist of joint. Man, aged 30.

I feel forced towards the view that all these latter theories are no more than theories with little or nothing to support them, and that in considering them we are going out of our way to find an explanation when we have trauma as a possible, and, in my opinion, probable, explanation of all the various conditions described above. Somner found a definite history of trauma in 7 of his 12 cases. In our own series, three-quarters gave a history of trauma—a blow or kick on the knee in 5, and a twist, football accident, etc., in 10; in 2 the history was indefinite; while in 4 only was there definitely no trauma. As already stated, the fragment may consist of nothing but *avascular* cartilage. By what possible process, other than direct trauma, can such a lesion occur in a joint which otherwise shows no change? That a considerable fragment can be broken off a condyle by a man's unaided efforts is proved by this

skiagram (*Fig.* 65). The patient, a man of 30, swung round somewhat abruptly to the right, to reach a book from a shelf behind him, his right foot being firmly planted on the floor. There was no question of external violence. Four weeks later a large fragment, quite free and obviously the result of a recent fracture, was removed from the back of the joint. Presumably this piece of the outer condyle was knocked off by the external tubercle of the tibial spine. The popliteus tendon was not attached to the fragment, which consisted of nothing but articular cartilage and bone.

As to those cases in which a typical lesion is seen in the radiogram and yet the cartilage is found intact, I can conceive it quite possible, as Hellström suggests, that the resilient cartilage, though bruised and damaged by a blow, might remain unbroken, and yet a fracture occur of the resistant and brittle bone beneath. Kappis speaks of a 'subchondral hæmatoma' being produced—surely quite a possible result of trauma, with or without a fracture of the bone. Panner[34] draws a rather attractive comparison with those cases of fracture of the carpal scaphoid in which the crack, seen only with the greatest difficulty soon after the injury, becomes obvious within a few weeks. Such a crack might easily be overlooked in the femoral condyle in a radiogram taken shortly after an injury. If a subchondral fracture occurs, it is quite possible for union to take place provided the movement of the fragment in its bed is minimal. Moreau[35] and Kappis both state that complete cure can occur with disappearance of the characteristic X-ray picture. If, however, the patient continues to indulge in violent exercise, the movement of the fragment may be more than minimal, and the fracture may remain ununited. Even when operation is delayed, therefore, the bony fragment may be found to be loose in spite of the cartilage being intact.

It remains for me to suggest an explanation of the lesion being found in the absence of a history of trauma. Supposing the initial damage left the cartilage unbroken, there would be no rough surface and no escape of blood to irritate the joint, and possibly no synovial effusion of any kind. It seems just possible that, in the heat of a game, the pain caused by the injury might attract but little attention, while later there would be no discomfort. Repeated subsequent traumata, perhaps not very severe, might break the cartilage and even gradually complete the separation of the fragment. Phemister makes the rather surprising assertion that the subchondral bone is peculiarly insensitive. He bases this statement on his experience when operating under local anæsthesia, saying that he had " chiselled off marginal osteophytes and small chips of cartilage and bone from the articular surface, apparently without producing any pain." It is evident, however, that he was dealing with grossly abnormal articular surfaces. Professor Blair was again consulted, but little work seems to have been done on the nerve-supply of bone. Further research is necessary before we can answer this question of sensitiveness of subchondral bone.

To sum up, I would suggest that the typical lesion is a fracture and nothing else, for the following reasons :—

1. It most frequently occurs in adolescents and young adults indulging in vigorous pastimes.

2. Typical lesions are seen in radiograms and revealed by operation after definite trauma, which in some cases is quite recent.

3. A lesion at the typical site may involve the cartilage only, the detached fragment consisting of normal articular cartilage. In such cases there is a definite history of trauma.

4. There is an entire absence of any inflammatory changes, macroscopic and microscopic, in or about the lesions.

5. The naked-eye appearances, when operation is performed early, suggest nothing but a simple recent fracture. When sufficient time has elapsed for changes to occur, they are only those which we should expect as the result of an effort on the part of the tissues to repair the damage. Precisely similar changes are occasionally found on the more exposed parts of the femoral articular surface, when the traumatic origin of the lesions is never disputed.

6. When the detached fragment is suspended by a vascular pedicle the bone in it is not dead, and is not a sequestrum, so why should it have been exfoliated ?

7. To explain the occurrence of the lesion in both knees, or in the knees of more than one member of a family, it is easier to accept the presence of anatomical peculiarities which favour exceptional local trauma than the suggestion of embolism, damage to blood-supply, or indeed any other theory.

TREATMENT.

Probably all will agree that in the absence of symptoms the finding of a typical lesion in a radiogram is not sufficient excuse for opening the joint. However, it is extremely unlikely that this discovery will be made except in the course of routine X-ray examination in a bilateral case, admittedly a very rare experience. I have found the lesion unexpectedly on routine X-ray examination in cases with a damaged semilunar cartilage. As already stated, disappearance of the lesion is possible. Hellström, however, advises operation in spite of the absence of symptoms, since otherwise, he says, osteo-arthritis will develop. This late complication cannot, I fear, be avoided, even by early operation.

In the presence of symptoms the joint should always be explored. If, on opening the joint, the articular surface is found to be unbroken, but the site of the lesion is clearly indicated by alteration in the colour or texture of the overlying cartilage, or the extent of the lesion is indicated by a groove, an attempt should be made to determine whether this circumscribed area of cartilage is movable or not. If it is, there seems no doubt about the wisdom of excising it, together with any loose bone beneath it. If the cartilage does not move over the bone, the problem is more difficult. Some surgeons I know would prefer to leave well alone. Personally I feel that the exact condition of the cartilage within the circumference of the lesion should be the determining factor. If definitely soft, sodden, and rough, although unbroken, I think it is better excised. Any bone found loose should be removed and the edges of the hole carefully bevelled. If, on the other hand, the cartilage is almost normal in appearance and the lesion

only just discernible, and there is nothing to suggest that a fragment of bone beneath is loose, it may safely be left alone. If in doubt, and particularly if the mobility or otherwise of the fragment beneath is uncertain, in my opinion it is wiser to excise the lesion. I should prefer to err on the side of radical treatment.

If the lesion presents the more usual appearance with the cartilage fractured, but with an unbroken portion holding the fragment more or less in position, the separation should be completed and the fragment removed. The cartilaginous margins of the crater should be carefully bevelled where necessary, and any undermined portions removed. I see nothing to be gained by curetting or otherwise treating the floor. There is no object in making the crater deeper. Any filling in that occurs will be done for the most part by the margins of the cartilage, and not by the bone, even though the latter be freshened by gouge or spoon. If the fragment is free in the joint and the X-ray shows the site from which it came, the incision should be planned to allow for inspection of the crater as well as removal of the loose body. In all cases the condition of the semilunar cartilages should be determined. In three of our cases a lesion of a semilunar cartilage (internal two, external one) was found in conjunction with the typical damage to the internal condyle.

The immediate *prognosis*, and for some years to follow, is undoubtedly good. The remote results one would hardly expect to be so favourable, and there is reason for believing that osteo-arthritic changes are certain to occur sooner or later.

SUMMARY.

In the above remarks I have briefly reviewed the known facts of the condition with special reference to the knee-joint, and have endeavoured to show that these point strongly to trauma, pure and simple, as the cause of the characteristic lesions. The mechanism of this trauma in the case of the knee-joint has been discussed, and it has been suggested that violent rotation inwards of the tibia, driving the tibial spine against the inner condyle, is responsible for the injury in most cases. I have ventured to give my own personal views as to the treatment suitable to the varying conditions which may be found on exploring the joint.

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THE ANATOMY OF THE PERIPHERAL SYMPATHETIC NERVOUS SYSTEM.

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Illustrations of the peripheral portion of the sympathetic nervous system have been designed either to show the physiological implications of its structure or to convey what appears to be the amazing complexity of its arrangements. Now that surgical resections of this system have become frequent, numerous publications bearing on its anatomy have appeared, and these seem to introduce a new kind of complexity. The complexity of the earlier representations arose from the picturing of rich arborizations amongst all the branches of the sympathetic nerves so that there resulted a bewildering interplexiform arrangement making it wellnigh impossible to determine how any particular organ might be deprived of its sympathetic innervation by surgical methods. The new complexity arises from the implication that there is no constant and formal pattern in the source of supply to the viscera, in that these may receive their innervation from adjacent plexuses or from branches proceeding from the ganglia, and further that a third source exists in the fibres which accompany the blood-vessels.

The object of the present paper is to review these suggestions and possibilities, and to determine with as much precision as possible the anatomical routes the nerves pursue, and how these can be approached and resected by the surgeon.

The well-known picture of Hirschfeld emphasizes the apparent complexity of the sympathetic nervous system. This picture has been used over and over again in various text-books and often modified to express some particular point of view. In the *Atlas* of Spalteholz and in Quain's *Anatomy* the representations of the sympathetic nervous system appear to be less complicated, and indeed we think our own investigations are more in accordance with the figures which appear in these books.

COMPARATIVE ANATOMY.

In order to grasp the morphological principles which underlie the peripheral distribution of the sympathetic system, it is necessary to refer briefly to its comparative anatomy and embryology.

The comparative anatomy of the system is not very well known, but what little information we have at our disposal goes to show that this system is a fairly late acquisition in the history of the animal kingdom. In *Petromyzon*, the most primitive of the chordates, a vagal system can be distinguished. Later comes an adumbration of the sacral outflow of

parasympathetic fibres. Then later in the history of the vertebrates the thoraco-lumbar portion of the sympathetic system proper makes its appearance. Therefore it is to be inferred that the autonomic system as a whole appears comparatively late, and of its three portions the sympathetic system (keeping this term for the thoraco-lumbar outflow) is the last of all to appear. It is interesting to observe that the same order is repeated in development, and in mammals the thoraco-lumbar portion of the autonomic system is the last to make its appearance.

As is well known, some of the cells belonging to the sympathetic nervous system become differentiated into adrenalin-producing cells. The totality of these cells which can liberate the sympathomimetic adrenalin is known as the 'chromaffin system'. The comparative anatomy of the sympathetic nervous system reveals that the chromaffin system is much more extensive in the lower vertebrates than in ourselves, and that it undergoes a progressive reduction as one passes up the animal scale. With this reduction in the extent of the chromaffin system there is a progressive increase in the peripheral plexuses of the sympathetic system. It would seem that in man the chromaffin system is still undergoing reduction, for those outlying chromaffin masses that lie beside the aorta and adjacent to the suprarenal, the para-aortic bodies of Zuckerkandl, disappear in the first few years after birth. The conversion of sympathetic medulloblasts into chromaffin-secreting cells has been a long-established embryological fact, and when Elliott established also that all fibres proceeding to the medulla of the suprarenal were preganglionic, it became clear that the rôle of adrenalin was the replacement of a postganglionic fibre by the distribution through the blood of a chemical substance. Obviously this method produces a diffuse response and is much slower than the more localized and swifter-moving nerve impulse. Thus it is clear, from the inverse relationship between these two modes of distributing sympathetic effects, that in the course of evolution the less exact has given way to the more precise and more highly differentiated method.

There are morphological reasons for suggesting that the visceral centres were first laid down in the hypothalamus, and exerted their effects on the periphery by means of the release of a chemical substance, and that out of this system has grown the peripheral sympathetic nervous system. Owing to its late arrival, parts of the neural axis had been already allotted to the extremities, and therefore it has become restricted in its outflow from the central axis to a range between the first thoracic and the third lumbar segment, and moreover its connector neuron became displaced to the periphery, for the only available source of neural proliferation was the neural crest. However, be this as it may, it is from the neural crest that cells of the sympathetic ganglia and the chromaffin cells take origin, thus arising from the same source as the dorsal ganglia of the cerebrospinal nerves.

The adrenalin produced in the chromaffin cells not only acts as a substitute for the fibre starting from the peripheral ganglion—that is, the postganglionic fibre—but also acts as an intermediary between the ending of the postganglionic fibre and the contractile or secreting element which it innervates. It seems possible that an adrenalin-like substance (called 'sympathin' by Cannon) does participate in every reaction produced by the sympathetic

fibres and is indeed the agent which produces the reaction. The fact that all sympathetic endings are pericellular and not intracellular is consistent with this idea. Therefore it is to be supposed that although the adrenalin as a replacer of sympathetic fibres is less in evidence in man than in lower vertebrates, the same does not obtain in the case of adrenalin or adrenalin-like substance acting as an intermediary between the nerve-ending and the reacting tissue.

The neuroblasts which are proliferated from the neural crest become aggregated in a segmental manner, so that in the postganglionic system of the sympathetic the metameric arrangement is preserved. A segmental plan does not occur in the preganglionic system, for this part, as is well known, is restricted roughly to the thoracic region of the cord. Its connections with the peripheral ganglia therefore show an overlapping. The extent and nature of this overlap was studied minutely by Langley, and from his work it can be concluded that each preganglionic fibre is likely to be connected with somewhere between three and six peripheral ganglia. This suggests that activity starting centrally is likely to have widespread effects at the periphery.

The peripheral distribution of the postganglionic fibres diverges into two great streams, one directed cranially and one directed caudally. The separation between the two systems is about the tenth thoracic segment. Those that pass cranially innervate the head and face, the eye, the heart, the lungs, and the upper extremity, in that order cranio-caudally. This is also the cranio-caudal order in which these structures arise in the course of development. The same is to be observed in the caudal region, for the succession in the sympathetic outflow proceeds to the abdomen, the pelvis, the lower limbs, and the perineal region.

To some extent morphological principles are exhibited in the peripheral fibres when their distribution is studied in relation to the emergence of the organs of the body in a transverse plane. As is well known, the trunk of the embryo in the earlier stages of its development shows three main regions in which are differentiated certain organ-systems of the body. These are distinguished most laterally as the somatopleure, from which the parietes of the abdominal wall are developed; in the median plane is found the splanchnopleure, which surrounds the entoderm of the gut; and between these dorsally a ridge of mesenchyme—the intermediate cell mass or the Wolffian ridge—in which the suprarenal, the kidney, and the gonad are developed.

Regarding the distribution of the sympathetic fibres to these areas, those for the parietes reach their peripheral destination by travelling in the spinal nerves. Those fibres which go to the structures derived from the Wolffian ridge come from a laterally placed ganglion—the renal ganglion, which is also the source of the fibres to the testis or ovary. The median entodermal structures have their ganglia piled along the front of the aorta, and the fibres from these accompany the blood-vessels to their end structures.

These three systems, which can be broadly distinguished morphologically, are also different physiologically. The parietal and limb fibres are vasomotor, sudomotor, and pilomotor; those to the intermediate structures, like the kidney and the testis, have no special function, for as yet nothing beyond

vasomotor effects has been discovered; those going to the mid-line structures are for the most part of an inhibitory nature, depressing secretion, inhibiting peristalsis, and dilating bronchioles; they are, of course, tonic to the sphincters.

In the abdomen this distinction between the three distributive arrangements can be apprehended most easily. The segmental ganglia are the source of the limb fibres, the intermediate organs have their own special group, while the great pre-aortic structures function for the alimentary system. The activity of the parietal group produces tonic constrictor effects, while the medial system is both vasoconstrictor and vasodilator to the blood-vessels, while being inhibitor to the circular and longitudinal muscle coats of the bowel.

From this brief review of the sympathetic system it can be inferred that it follows definite morphological principles, and that in its peripheral distribution we may hope to be able to determine well-marked and definite concourses of fibres so arranged that it can be said that their removal would result in the denervation of precise regions of the body. This view is to some extent in conflict with the work of other anatomists, whose investigations have led them to emphasize the syncytial aspects of the sympathetic systems. Nor does it readily harmonize with the work of Kondratjew, who has emphasized the existence of interorganal plexuses between adjacent viscera within the abdomen.

We would now proceed to discuss the anatomy of the sympathetic system in some of the regions of more immediate interest to the surgeon.

THE SYMPATHETIC INNERVATION OF THE EYE.

The nodal point in the origin and distribution of the peripheral fibres to those parts of the body above the diaphragm is the ganglion stellatum. By this we mean the inferior cervical ganglion and the first thoracic. These are so often fused and the distinction between them is often so slight that the term 'ganglion stellatum' can be used quite justifiably. This ganglion, along with the outlying middle and superior ganglia, really represents fused segmental and prevertebral ganglia—that is, it has the combined significance of, say, the lumbar and the cœliac ganglia in the abdomen. From it proceed segmental rami as well as visceral branches such as the cardiac accelerators. It was for these reasons that Gaskell was tempted to apply the term 'superior splanchnic' to the cervical sympathetic.

From the stellate ganglion the peripheral fibres directly or indirectly proceed farther. Of these fibres some will proceed as preganglionic fibres to the middle and superior cervical ganglia; others, the majority, will emerge from it as postganglionic fibres. Those which proceed to the eye, for instance, pass into the cervical sympathetic, traversing the stellate ganglion and then passing in front of the subclavian artery. When they reach the superior cervical ganglion they enter into synaptic arrangement with the cells of this ganglion. Thereafter they reach the cavernous plexus by travelling with the internal carotid, and from there reach the extrinsic unstriped muscle of the orbit as well as the dilator fibres of the pupil. On these they exert a continuous

tonic effect, for as soon as they are interrupted the well-known phenomena of Horner's syndrome make their appearance.

These ocular sympathetic fibres are of interest for several reasons. The enophthalmos, the narrowing of the palpebral fissure, the lowering of intra-ocular pressure, and the constrictor effect on the pupil (due to unopposed action of the parasympathetic fibres of the third nerve) follow whenever the preganglionic or the postganglionic fibres are divided. This means that the superior cervical ganglion and its fibres, when isolated from their preganglionic connections, exert no influence on the smooth muscle of the orbit. The peripheral ganglia are not centres from which reflex effects can be initiated. It is true that this question has been investigated often and much discussed, but the laboratory observations and the surgical results seem to be in agreement that the isolated peripheral sympathetic ganglia are inactive when severed from their spinal connections.

The ocular effects are continuous and have been observed for several years after removal of the stellate ganglion, i.e., by breaking their preganglionic connections. All sympathetic effects are not continuous and tonic. The ocular and vasoconstrictor belong to this group, and also perhaps the pilomotor and the sudomotor. Sweating, however, is somewhat complicated, for there is a sweating that depends on the spinal nerves, that is activated by pilocarpine and inhibited by atropine—a parasympathetic resemblance. It is well known that adrenalin, the normal sympathomimetic drug of the body, does not activate the sweat glands. The effects on the unstriped muscle and glands of the alimentary system would appear to be occasional and not of a continuous tonic nature. This distinction is of importance, for obviously surgical intervention is likely to be more effective when it is directed to the removal of the continuous tonic effects.

The anatomical pathway of the distribution illustrates another aspect of the peripheral sympathetic system. The nerve-fibres reach their destination by travelling with the blood-vessels. This would seem to be the usual way in the case of the viscera. For the visceral structures we have long preganglionic pathways—the cervical sympathetic pathway in part, the great splanchnic, and the hypogastric nerves (the presacral). These encounter peripheral ganglia : the superior cervical ganglion, the cœliac and the inferior mesenteric ganglion, together with the cells in the superior hypogastric plexus. From these ganglia then proceed the final fibres, and these reach their destination by travelling with the blood-vessels. This is in marked contrast with the distribution to the parietes and limbs, where the fibres can be observed as grey rami joining the segmental spinal nerves.

The evidence from morphology and function set out above induces us to suggest that these two modes of distribution represent a real distinction in the arrangement of the sympathetic nervous system, and that each part, the somatic and the visceral, preserves its characteristic mode. The ocular effects are so certain and easily recognizable that they can be used, if necessary, as a criterion for the anatomical success of a cervical sympathectomy. The presence or absence of Horner's syndrome makes it certain whether the cervical sympathetic has been divided and the stellate ganglion removed or not.

We have referred to the restriction of the spinal-cord area from which the preganglionic fibres to the peripheral ganglia start. Mention has been made of the fact that each preganglionic fibre subserves several peripheral ganglia. Further, if we inquire into the higher centres which activate the lower spinal centres we should find them congregated in a small area in the hypothalamus. Thus we are prepared for the reception of the notion that a third and possibly the most important activity of the sympathetic system is its total emergency response. This aspect, though of the greatest importance, is not germane to our present intentions, for it is outside the scope of surgical intervention. We mention it now to invite attention to the threefold quality of sympathetic activity: the continuous tonic aspect, which offers reasonable hope that surgical intervention may be profitable; the occasional, such as the effects on the gut, where the results of surgical intervention are perhaps less likely to be reliable; and the total emergency response, which is outside the scope of surgery. A piecemeal intervention is not likely to hurt this last response, for the peripheral-fibre system is helped out by the production of adrenalin.

Two deductions from this are of further surgical interest—namely, the anatomy of the system and the results of physiological investigation do not suggest that local diseases are likely to find their explanation in hyper-activity or hypo-activity of small parts of the peripheral system. The effect most likely to be achieved by surgery is an indirect one—namely, an increase in the amount of blood flowing to a particular region through the removal of vasoconstrictor tonic impulses. Tonic impulses to smooth muscles, either activatory or inhibitory, could be removed, but beyond such effects as these there is no evidence at the moment that more can be achieved.

THE SYMPATHETIC INNERVATION OF THE UPPER LIMB.

The sympathetic innervation of the upper limb leads us to examine in the first instance the origin of the rami and their connection with the spinal nerves that make up the brachial plexus.

It is possible for a body structure to receive sympathetic fibres by three routes: (1) By incorporation with the peripheral spinal nerves and thus sharing in their distribution; (2) By proceeding with the blood-vessels; (3) By direct distribution to the organ without joining other kinds of nerves or accompanying blood-vessels. The last way arises in the case of some of the abdominal and pelvic viscera. In the limb, only the two former arise.

The Vascular Route.—The opinion that the vascular route is used by sympathetic fibres has diffused widely following the observations and surgical reports of Leriche. Actual observation discloses, of course, the penetration of the spinal nerves by the rami; it shows fibres from peripheral nerves joining blood-vessels, which in accordance with ordinary dissecting-room procedure may fairly be called branches of vascular distribution. Numerous nerve-fibres, in the form of fasciculi, running for considerable distances, can also be observed in the adventitia of blood-vessels; and finally in the tunica media

a continuous nerve plexus can be seen extending throughout the whole of the vascular tree. Moreover, by the ordinary method of dissection aided by a binocular, it is possible to trace some fibres for a short distance on stem-vessels like the subclavian and the iliac arteries. The fewness of the fibres and the difficulty of the dissection here is in marked contrast with the ease of tracing such nerves on the carotid or splanchnic vessels, for instance.

The method of dissection by exposing the rami and the branches of vascular distribution from adjacent nerves suggests strongly that in the limbs the sympathetic fibres reach their destination through the spinal nerves. The investigations of Langley, Woollard, and others have brought experimental confirmation of this, and we believe that surgical opinion is now in alinement with this view.

Perhaps the simplest and most convincing demonstration of the fact that the blood-vessels of an extremity get their innervation from the sympathetic fibres in the adjacent nerves is to inject a peripheral nerve, such as the median or ulnar, with novocain. Along with the anæsthesia a paralysis of the sympathetic fibres occurs, and the removal of constrictor impulses discloses itself in vasodilatation, producing a flush and a rise of temperature. In this way it can easily be shown that the vasodilatation coincides with the peripheral distribution of these nerves, and in the case of the ulnar a difference of temperature can be shown, by using a thermo-couple, between the two sides of the ring finger (Woollard and Phillips). The method of cocainization of peripheral nerves, or of spinal anæsthesia, or the production of protein reaction (typhoid vaccine), has been used as a clinical test to determine the part which sympathetic impulses are playing in the production of particular lesions.

The converse method of infiltrating the adventitia of blood-vessels like the radial artery gives no vasodilator response. It can be concluded with certainty that the experimental, the degenerative, and the dissecting methods all agree in deciding that the blood-vessels of a limb receive their sympathetic fibres by distribution from adjacent nerves.

Since, however, there is demonstrable a continuous plexus in the media of blood-vessels, it might be supposed that this could afford a chance for impulses to proceed upwards or downwards within it. This plexus is unlike a conducting system. It gives off pericellular endings to the unstriped muscle fibres. Impulses which enter this plexus extend over a small area and then die out. Though its appearance suggests continuity, yet the arrangement is of such a nature that its purpose is to subserve a restricted portion of the vascular tree, and experiment shows that impulses soon die out within this area and are not transmitted for any distance upwards or downwards.

The nature of the intrinsic plexuses is of some importance, for we encounter a similar arrangement in the ureter. This will be mentioned again later. But it is necessary to emphasize at the moment that organs and blood-vessels have no break in the continuity of their intrinsic plexuses, and that these function locally, while from the periphery come the fibres whose subdivisions form these plexuses.

THE ANATOMY OF THE RAMI AND THE GANGLIA.

The number, arrangement, and apparent source of the rami, as well as the cervical sympathetic ganglia themselves, exhibit considerable variation. Potts, Axford, and others have recorded from their dissections variations in the number of rami, and the inconstancy of their relations to adjacent muscles. Our own observations are in agreement with the results they reached. The feasibility of such operations as ramisectomy must be determined in large part by the assortment of these sympathetic branches, and also the variations encountered raise the problem whether any significance attaches to the number of these rami.

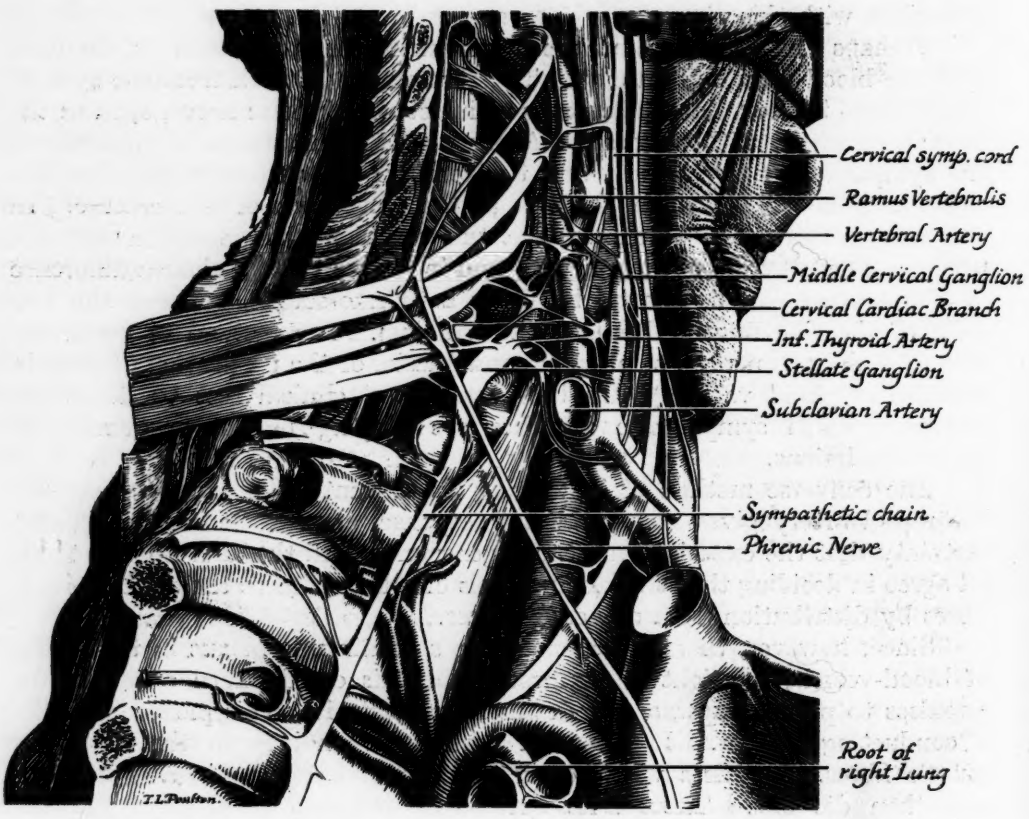

FIG. 66.—Dissection showing the connections of the lower cervical sympathetic system.

The teaching commonly imparted of the anatomy of the cervical sympathetic would lead one to suppose that the inferior cervical ganglion and the first thoracic ganglion are discrete masses, but such would seem rarely to be the case. Most often it is found that an elongated ovoid mass is situated in front of the neck of the first rib near the costocentral articulation, and that this mass, when traced upwards to the lateral angle between the vertebral artery and its origin from the subclavian, emits a stream of fibres in which one or more small ganglionic masses are entangled. It is an economy to

apply the term 'stellate ganglion' to all these ganglionic accumulations rather than to attempt to delimit one part as first thoracic, another as inferior cervical, and another as the middle cervical ganglion.

By references to the accompanying figures (*Figs.* 66, 67), it can readily be apprehended that the ganglionic masses, in order to be exposed, need division of the scalenus anticus muscle, displacement of the subclavian artery, and the separation of the extrapleural tissues from the medial border of the

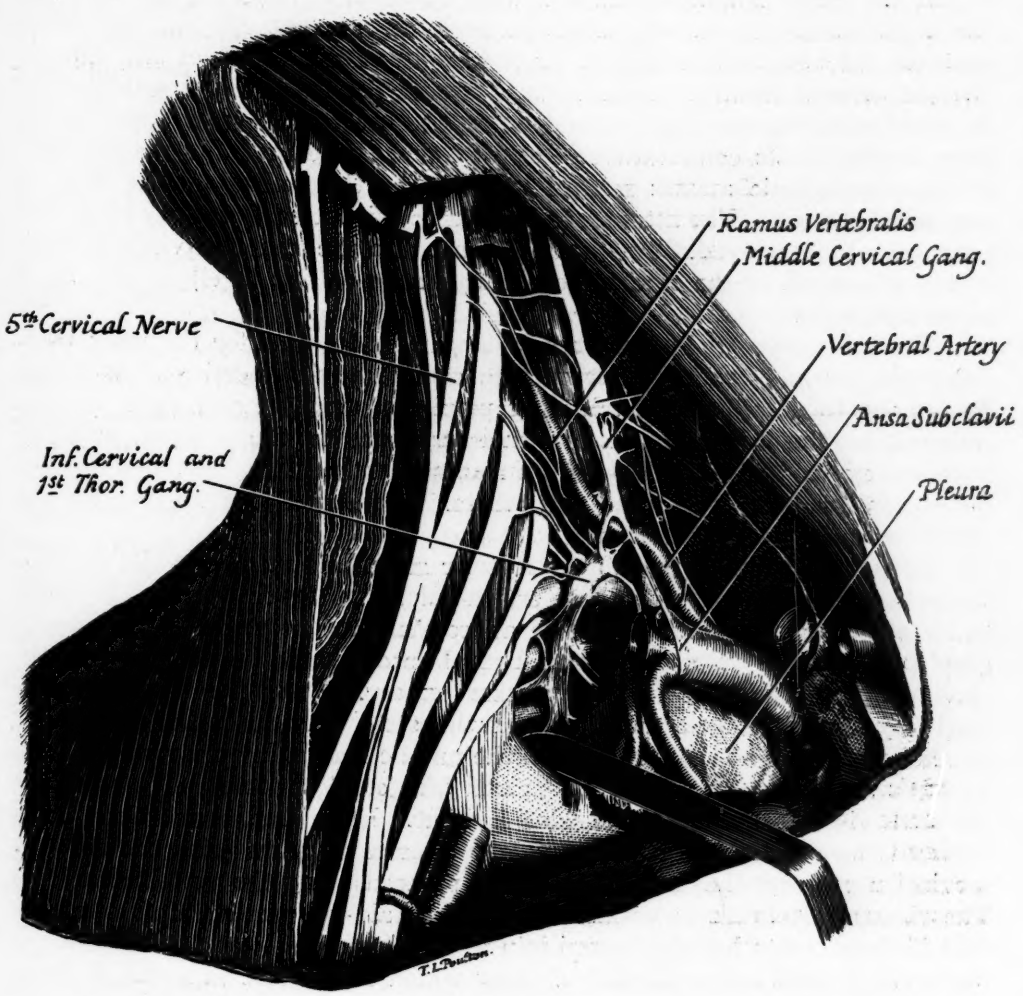

FIG. 67.—A dissection showing the positions and connections of the middle cervical and stellate ganglia.

first rib. The lower pole of the ganglionic mass leads directly downwards and backwards to the second thoracic ganglion, which lies opposite the medial extremity of the first intercostal space and usually extends to the upper border of the second rib.

The middle cervical ganglion is a very uncertain topographical mass. It is usually assigned to a place where the cervical sympathetic chain crosses

the inferior thyroid artery opposite the sixth cervical vertebra. Reference to the same figures (*Figs.* 66, 67) will show that in one case (*Fig.* 66) the mass labelled 'middle cervical ganglion' is an inconspicuous thickening on the cervical chain, while in the second case (*Fig.* 67) it forms a mass easily divisible into upper and lower portions. Since the middle cervical ganglion is such a fluctuating quantity, similar variation must occur in the origin and course of the rami to the fifth and sixth cervical nerves which are usually attributed to it.

If the term 'ganglion stellatum' were extended to cover all the large and small ganglionic masses opposite the neck of the first rib and extending upwards into the angles formed by the origin of the vertebral and inferior thyroid arteries from the subclavian, it would get rid of some artificialities in descriptive anatomy and would make the use of the term approximate more nearly to its connotation in comparative anatomy. The irregularities of these ganglionic masses remind us more of the cœliac plexus than of segmental ganglia. The attempt to emphasize this latter aspect has led to the terms usually employed. They are of course also the source of visceral fibres (most, if not all, of the cardiac accelerators arise at this level) as well as of segmental rami.

The rami take origin from the main ganglionic mass for the most part, but some come as well from the more cranially lying portions. It would be tedious to describe in detail their plexiform arrangement, their varying relations to the adjacent muscles, their relations to the arteries, and the inconstancy in their number and apparent origin. Excellent descriptions have been furnished by Axford and others. It will suffice if we describe the results of one of our dissections.

In this specimen (*Fig.* 67) the inferior ganglionic masses in the cervicothoracic region consist of an upper, middle, and lower mass. The term 'middle cervical ganglion' would be appropriate to the upper two on topographical grounds. The connecting links between these lie behind the subclavian artery and encircle the vertebral artery. From the upper mass a single ramus joins both the fifth and the sixth cervical roots. A medial visceral ramus is also present. From the middle mass a large ramus proceeds upwards and outwards to the fourth and fifth cervical roots. Two medially directed visceral branches are also present. From the connecting fibres between the middle and lower ganglionic masses a ramus joins the seventh cervical nerve and the ramus vertebralis proceeds with the vertebral artery. The ramus vertebralis is variable in size but always present, and furnishes an additional route by which rami join the upper cervical roots. These enter the cervical roots independently of those which come more superficially from the ganglia. The lowest ganglionic collection supplies a small ramus to the sixth cervical, and a larger ramus is distributed to the sixth, seventh, and eighth cervical nerves. A separate small ramus proceeds to the first thoracic nerve. In addition there are, of course, visceral branches.

Kuntz has drawn attention to the occasional presence of an additional ramus to the first thoracic nerve from the second thoracic ganglion. This ramus we have encountered on one occasion. Its frequency is great enough to impose always on the surgeon the need for designing his cervical sympathectomy operations in such a way as to destroy this ramus.

It is clear from this compendium that the rami are more numerous and more widespread than might have been supposed. Further, they have a widespread origin from a stellate ganglion or from the more separate masses (first thoracic ganglion and inferior cervical ganglion), from the cervical sympathetic at, below, or above the supposed position of the middle cervical ganglion, and from the ramus vertebralis. Again, rami may be separate at their origin and conjoin later, or, on the other hand, a ramus of single origin divides and so supplies more than one spinal nerve.

These several rami enter into the spinal nerves over varying intervals, and may pass in front or through the prevertebral muscles and the scalenus anticus. Thus, on anatomical grounds it would be hard to believe that the operation of ramisectomy, i.e., the cutting off of the sympathetic fibres to the limb by division of the rami, would ever be complete. There are, of course, other reasons for directing the surgical intervention elsewhere.

We have so far proceeded on the assumption that all these rami are postganglionic, i.e., that they have come from the cord not higher than the first thoracic ventral root and have their cell stations in the ganglia above described. This piece of anatomy rests, we believe, on a quite secure basis, but there are not wanting observers who would elevate the level in the spinal cord from which such fibres might come. Winkler, for instance, on histological grounds, has suggested that such fibres might reach the upper part of the cervical sympathetic by way of the spinal accessory. This is highly improbable, and a re-examination of the ventral roots for finely medullated fibres brought us to the same conclusion as Harman long ago reached—namely, that ordinarily the first thoracic ventral root is the first root in which such fibres become conspicuous. This morphological test by itself is not conclusive, for finely medullated fibres which are not sympathetic but motor in function exist in all ventral roots (Sherrington). These are few and scattered, however, and the morphological picture of the first thoracic root contrasts strongly with those preceding it.

Harman drew attention to the fact that the sympathetic outflow does vary, however, with the fixation of the plexus. If this moves forwards a segment, then the preganglionic outflow shifts to the eighth cervical segment, or if post-fixed the second thoracic root becomes the most cranial level of the outflow. This, we think, explains the occasional contribution from the second thoracic ganglion to the first dorsal nerve, to which Kuntz has directed attention. The number of rami exposed by a dissection is not by any means a measure of the number of sympathetic fibres joining the spinal cord. Some of the rami really consist of a small blood-vessel and a few fibres. The usual method of dissection is likely to be complicated by the presence of more or less fibrous tissue, and, indeed, a fibrous strand may be so dissected as to be mistaken for a nerve-fibre. Histological investigation is necessary as well, in order to determine the true composition of the rami exposed by dissection. This does reveal that some of the rami found by dissection may owe their apparent size to fibrous tissue or to the presence of a small blood-vessel and contain but few nerve-fibres. The nerve-fibres are almost entirely non-medullated, but in some rami there will be found a few fibres that have not yet lost their medullary sheaths. Despite the presence of medullation,

it is justifiable to assume that these are postganglionic fibres, for a similar state has been noted in other parts of the body in fibres definitely known to be postganglionic.

As has already been mentioned, the evidence justifies us in believing that these rami undergo along with the other nerve components of the brachial plexus the same reassortment and arrangement, and thus have the same distribution.

Since also it is known that the vasomotor supply is most abundant to the more superficial vessels, and, of course, the pilomotors and sudomotors are entirely cutaneous, we might infer, therefore, that those spinal segments which innervate the largest cutaneous areas would contain the greatest number of sympathetic fibres. Actual observations suggest that the largest number enter the eighth cervical root in the brachial plexus and the first sacral in the lumbo-sacral plexus, i.e., to the hand and foot regions.

Though ramisectomy would be justified on physiological grounds, the anatomical difficulties of achieving a sympathetic denervation in this way are, as already pointed out, very considerable. There is, however, another reason why ramisectomy is unsuitable. The vascular changes and the ocular effects which follow sympathectomy have now been observed for a long time after operation, and Adson and Hesse have noted that they are present for two to three years. This means practically that they endure indefinitely. This would, of course, not be so if regeneration could occur. Enough clinical evidence is now available to make it likely that such regeneration does occur after ramisectomy and may be practically complete in a year or so.

From these observations and the experience now available, it can be concluded that the only way to denervate the upper limb of its sympathetic fibres, to avoid all regeneration, and to ensure a permanent state of relative vasodilatation, is to remove those masses comprised in the term 'ganglion stellatum', i.e., the inferior cervical ganglion and the first thoracic ganglion of ordinary anatomy. Since the second thoracic ganglion occasionally makes a contribution to the sympathetic innervation of the upper limb, this should be included also. The problem of the most advantageous approach, from the front or the back, we do not propose to discuss, since other than anatomical considerations arise. We can assert, however, that the anterior approach has been completely successful on many occasions in the Surgical Unit of St. Bartholomew's Hospital, and subsequent dissection of the excised tissue has proved that the second thoracic ganglion has been removed.

THE SYMPATHETIC INNERVATION OF THE DISTAL PART OF THE COLON.

The mode of sympathetic innervation of the gut stands in sharp contrast to that of the limbs. For in the alimentary tract the ganglia from which the peripheral fibres start are piled up along the front of the aorta. These ganglia are fed by preganglionic nerves which travel relatively a very long distance before they reach their synaptic terminations. The peripheral fibres run in close association with the blood-vessels in order to reach their destination. The nodal ganglionic point in the case of the descending colon, the

iliac colon, the pelvic colon, and the rectum is the inferior mesenteric ganglion. This perhaps needs some qualification in the case of the rectum and distal part of the pelvic colon, for there occurs here a slender reinforcement of sympathetic filaments derived from the hypogastric and pelvic plexus. The inferior mesenteric ganglion is, however, not a discrete mass, and its scattered elements may have an extensive range. They may be found proximal to as well as at the level and distal to the origin of the inferior mesenteric artery. Scattered cells are also found in the hypogastric plexus. The fibres coming to this ganglion are derived in chief part from filaments which descend along the anterior surface of the aorta, having passed through the cœliac plexus. In their descent they form a pre-aortic plexus. In addition, branches are given to the inferior mesenteric plexus from the second and third lumbar ganglia on each side. These pass forwards and downwards behind the beginning of the inferior mesenteric artery to mingle with the other fibres of the inferior mesenteric ganglion. The inferior mesenteric plexus thus constituted then subdivides so that each branch of the inferior mesenteric artery is accompanied by several large filaments. Those which accompany the superior hæmorrhoidal artery cross the common iliac vessels and eventually form a plexus behind the rectum in a plane anterior to that of the hypogastric nerves. These two plexuses communicate a few fibres running between the superior hæmorrhoidal plexus and the hypogastric plexus. To deprive those portions of the gut which lie within the vascular bed of the inferior mesenteric artery of their sympathetic nerve supply, it would therefore be necessary to remove the inferior mesenteric ganglion. To render the denervation as certain as possible, the dissection should be extensive and should be made proximal to the origin of the artery by removing the adventitia from the front of the aorta. In order to secure the contributions from the lumbar ganglia, the inferior mesenteric artery should be stripped of its adventitia for a short distance from its origin. Since the hypogastric plexus contributes some fibres to the superior hæmorrhoidal plexus, this also should be included in the resection.

The anatomical considerations are not entirely ended by breaking the sympathetic fibres at the level of the inferior mesenteric ganglion. As is well known, there exists in the gut the intrinsic plexuses of Auerbach and Meissner. The anatomical relationship of these intrinsic plexuses to the extrinsic nerves of the gut, such as the vagal and sacral parasympathetic and the sympathetic nerves just described, is, in our opinion, quite unsettled. Without opening up the whole question in these pages, we would content ourselves by asserting that there is at the present time no justification for removing it from the separate category in which Langley placed it—namely, that portion of the autonomic nervous system which he called the 'enteric nervous system'. The matter is important, for it affects the view we must take in regard to the motility and vasomotor reactions of the gut. There is, of course, abundant evidence of the presence of vasoconstrictors in the gut, but there is also evidence of vasodilator fibres as well. In regard to the gut movements, opinion has crystallized around the conception that the segmental movements are myogenic in origin, the peristaltic are due to the intrinsic nervous plexuses, and the extrinsic systems, like the sympathetic and parasympathetic,

are regulatory in function. Thus the sympathetic, when stimulated, inhibits the peristaltic movement of the gut, and, almost as a necessary concomitant of this, enhances the tonic activity of the sphincters. The pathological evidence gained from the study of the achalasias, though as yet we think not conclusive nor yet analysable into cause and effect, does suggest that degeneration of the intrinsic plexuses is associated with these. In any case, whatever be the interpretation of these changes in the intrinsic plexuses, they are outside the range of surgical intervention, and so the soundness of operations on the sympathetic nervous system for these disorders of gut motility must depend on clinical observations.

INNERVATION OF THE BLADDER AND URETER.

Although the more important anatomical features of the innervation of the bladder are known, there are still some points which need further elucidation. The principal sources of the nerves of the bladder are by way of the hypogastric (presacral) nerves and plexuses and by way of the sacral parasympathetic nerves (pelvic nerves). The pudic nerve is the sensory nerve of the urethra and the motor nerve of the external sphincter of the bladder. Since the external sphincter of the bladder, especially in women, contains a considerable number of unstriped muscle fibres, there must be some overlap in the motor elements of the three nerves supplying the bladder. The sacral parasympathetic nerves to the bladder contain the most important afferent and efferent nerves that have to do with micturition, and therefore cannot be touched by the surgeon. In those cases where it would appear that the difficulty in micturition is due to the inability to relax the external sphincter, some relief might be expected to follow a partial resection (avoiding the branches to the anal sphincter) of the pudic nerve.

At the moment surgical intervention is directed most usefully to the sympathetic fibres that reach the pelvic viscera by way of the hypogastric nerve. It is necessary to consider, in view of the anatomical results of other investigators, if this is the only route by which such fibres travel. Another source which has been mentioned is by fibres passing directly to the bladder and other viscera of the pelvis from the chain of sacral sympathetic ganglia. Our own dissections have been especially directed to this point and occasionally we have come across such connections, but they are not constant. When they are present they are extremely small. We have doubted whether such connections are real in the sense of containing nerve-fibres, but histological examination has proved that they contain a few. We are of opinion that this source of fibres is inconstant, that at most only a few fibres pass by this route, and that it may well be that these are used entirely for the innervation of adjacent small blood-vessels.

Observations on the Formation and Distribution of the Hypogastric Nerves.—Another route has been postulated, chiefly by French surgeons—namely, that sympathetic fibres reach the pelvic viscera by travelling along the blood-vessels. We have already remarked on the fact that when this route is the channel for the peripheral distribution such a route is easily identified by the ordinary method of dissection (*Fig.* 68), which shows the

nerve-fibres accompanying the superior hæmorrhoidal artery. When such fibres are not so seen we are really confronted by the same problem which has been raised and solved in the case of the limbs. The continuous innerva-

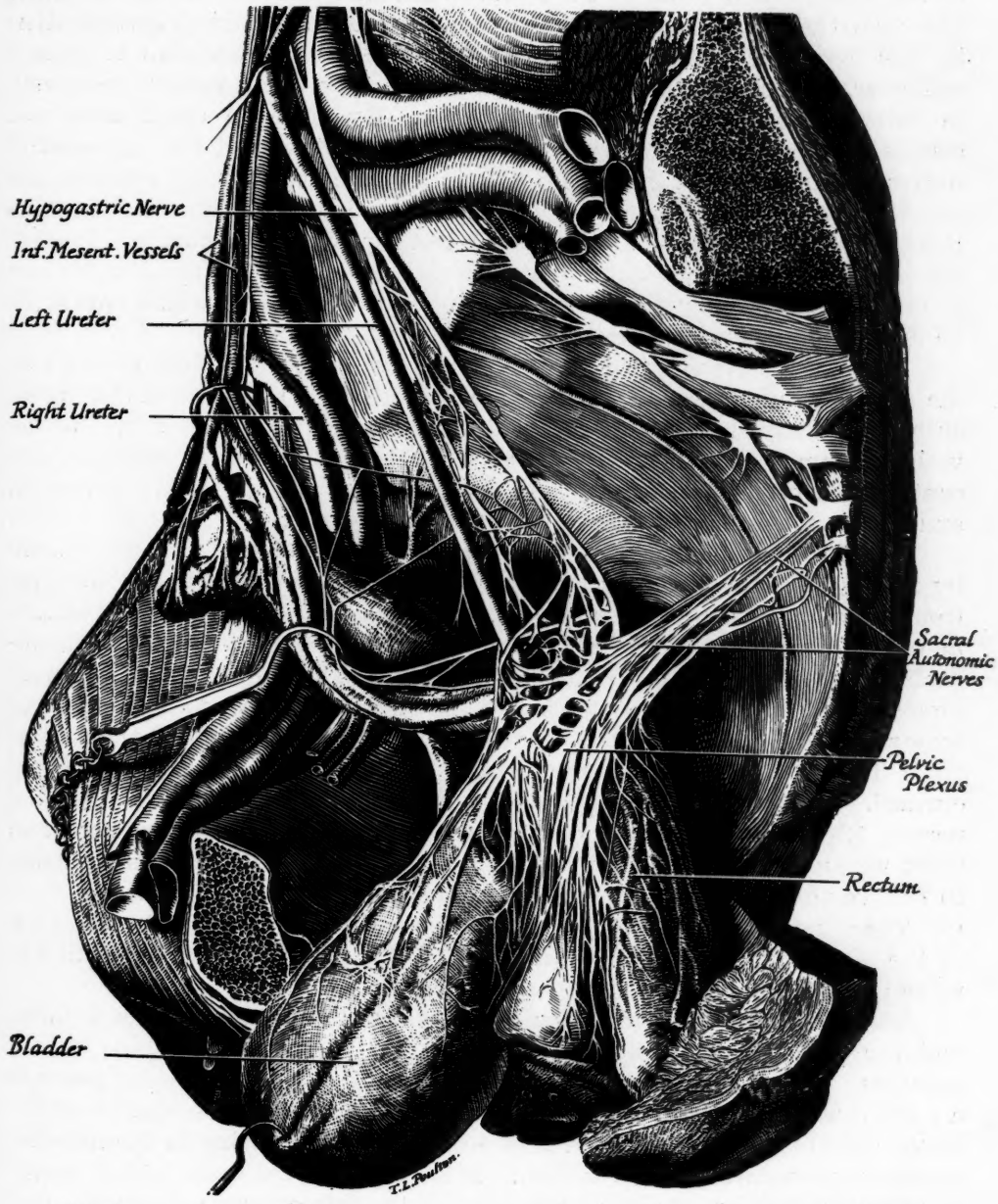

FIG. 68.—A dissection showing the distribution of the hypogastric and pelvic nerves.

tion by an intrinsic nerve net in the blood-vessel is the mode of local innervation and not the method of transmitting impulses to a distance either in the blood-vessels themselves or to the structures which they supply. Thus we

believe that practical surgery is best served at the moment by a knowledge of the anatomy and physiology of the hypogastric nerves.

These hypogastric nerves are believed to be inhibitory to the detrusor of the bladder and tonic to the so-called internal sphincter of the bladder. One uses the qualifying phrase 'so-called' because anatomical investigation in this department throws some doubt on the usual conception of such a sphincter. However, this does not affect the way these nerves co-operate in determining the action of the bladder. Both animal experiment and surgical intervention go to prove that this contribution of the hypogastric nerves to the function of the bladder is not one which need prohibit the intervention of the surgeon. A slight increase in frequency of micturition is the usual result of its removal and even this is probably temporary. Indeed, this result is an indication for resection of this nerve, for there occur cases of difficulty of starting the action of emptying the bladder which appear to be due to too much inhibition through the hypogastric.

These same nerves are also vasoconstrictive, and this action emerges as the opposite function of the sacral parasympathetic ('pelvic nerves' of some authors, also called 'nervi erigentes'). Further, they are motor nerves to the vesiculæ seminales and prostatic gland. Thus after their exclusion the contribution of these organs by which the seminal fluid is formed is absent, and so the male may be sterile though not impotent.

There is evidence that afferent fibres reach the central nervous system by passing through the hypogastric nerves. This evidence has been obtained from the study of spinal cases in man. Riddoch and Head observed patients in whom, through spinal injury, all nerves to the bladder except the hypogastric nerves were cut off from the higher centre, and found that they were aware of the state of the distension of the bladder. Learmonth divided the hypogastric nerve in man, using local anæsthesia, and stimulated the central end. The patient complained of a pain in his bladder as though it were being crushed. Histological investigation shows the presence of large medullated nerves, 12 to 15 μ in diameter. In the light of the foregoing evidence and what we know of the anatomy of sympathetic fibres it is not unreasonable to believe that these large medullated fibres are sensory in function.

The Anatomy of the Hypogastric Nerves (Presacral Nerves).—In view of the foregoing comments on the anatomy, we present in some detail the results of our dissections.

The hypogastric nerves vary considerably in arrangement and form, and the following observations have been derived from the study of six cadavers. Despite the individual variation, the general arrangement presents a fairly constant pattern. In three specimens (*see Fig.* 68) dissected by us the nerve consists of a single strand 2 to 4 mm. in breadth lying in the mid-line across the promontory of the sacrum. It is formed by the union of two nerves of approximately equal size at the level of the left common iliac vein, and lies in a separate fascial stratum in front of the middle sacral artery. It is surrounded by a variable amount of fat. Below, the nerve spreads out into a plexiform network of fibres placed over the first sacral vertebra and upper part of the second. Above, the two roots are derived from a plexus situated on the front of the aorta. The root of the right side receives fibres from the

second and third lumbar ganglia and from the pre-aortic plexus. The strands arriving from the right ganglia are seen to pass behind the inferior vena cava on to the front of the aorta. The root of the left side is formed in part from the inferior mesenteric ganglion and in part from the branches derived from the second and third lumbar ganglia, these latter passing behind the origin of the inferior mesenteric artery in order to reach the left hypogastric nerve. The right and left nerves so formed then cross the common iliac artery of

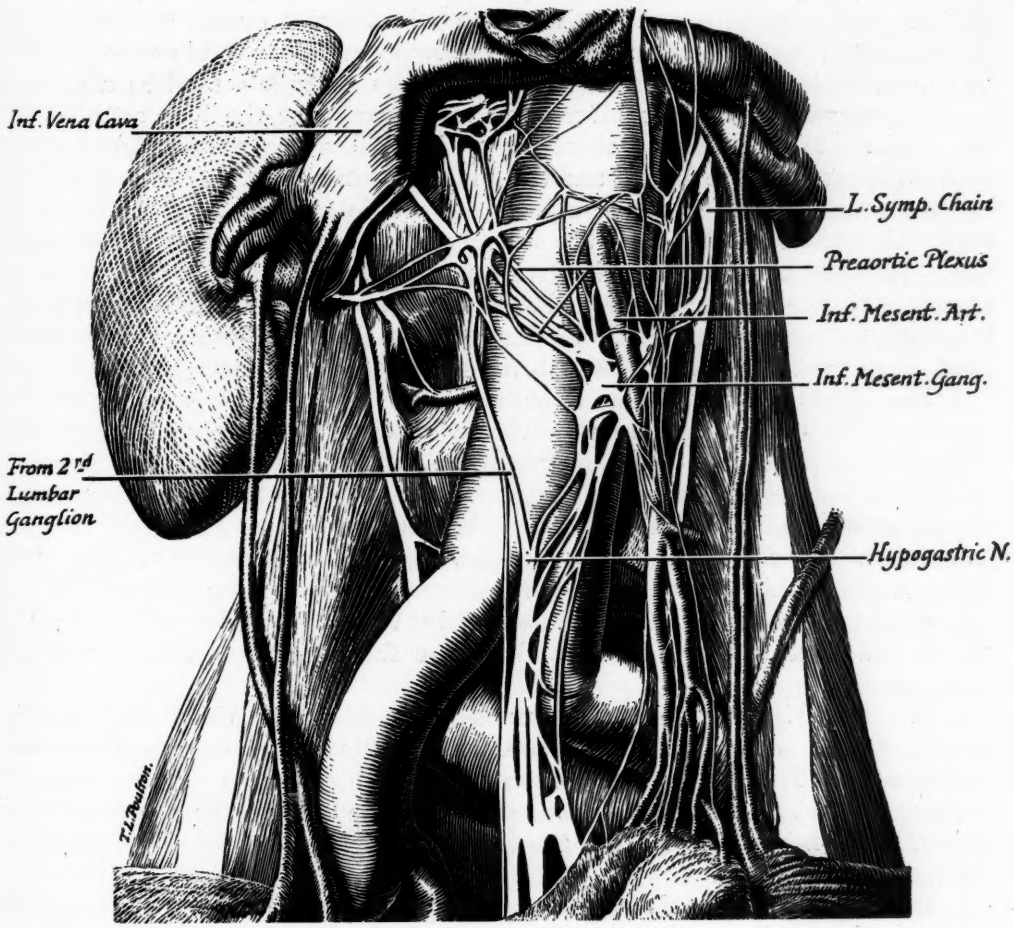

FIG. 69.—A dissection showing the position and connections of the inferior mesenteric ganglion and the formation of the hypogastric nerves.

their respective sides and join at or near the lower border of the left common iliac vein.

In one of our specimens (*Fig.* 69) the hypogastric nerve was present as a broad band placed on the left common vein and formed by the coalescence of seven different contributions. One of these, the largest, descended on the right side of the aorta from the pre-aortic plexus. It was joined by six smaller branches which crossed together the left common iliac artery from the inferior mesenteric ganglion. This group represents the simpler left

single radicle in the previous specimens. Almost directly after its formation the hypogastric nerve breaks up into a plexus in front of the first piece of the sacrum.

Intermediate in type between these were two specimens showing the formation of the two main roots which form the hypogastric or presacral nerves from a lesser number of contributory fibres. In one a branch of fairly large size passed on the left side behind the left common iliac artery from the inferior mesenteric ganglion to join the plexus resulting from the subdivision of the main nerve. This branch might easily escape the surgeon. In summary it may be said: (1) That the hypogastric nerve is derived from two main roots. (2) These two roots vary from a single strand to a group of fibres crossing either the bifurcation of the aorta or the iliac arteries of each side. (3) The right root comes mainly from the aortic plexus and receives fibres from the second and third lumbar ganglia of that side. (4) The left root comes partly from the inferior mesenteric ganglion, partly from the aortic plexus, and partly from the second and third lumbar ganglion of that side. (5) One or more branches may pass behind the left common iliac artery. (6) The hypogastric nerve lies in a separate stratum of fascia and may be embedded in a considerable amount of fat. In one specimen only were fibres found passing from the fourth lumbar ganglion on each side.

The Pelvic Plexus.—The hypogastric plexus in front of the sacral vertebræ divides into two general divisions which pass laterally and forwards behind the peritoneum of the recto-vesical or recto-uterine pouch. In two specimens the nerves were found to be fairly close to the peritoneum. Reaching the region of the base of the bladder a series of fibres, six to ten in number, were found to turn up on the vesical end of the ureter and to run upwards along this structure. A dense interlacing plexus was formed at the side of the prostate and bladder base fed by the hypogastric passing downwards and laterally from above and by the sacral parasympathetic nerves from behind.

The sacral parasympathetic nerves come from the third and fourth sacral nerves; occasionally an additional rootlet comes from the second sacral nerve. These nerves are composed of six to eight considerable strands on each side, 1½ in. in length, passing on either side of the rectum and in close proximity to it. They lie below the level of the reflection of the peritoneum on each side.

In two specimens only a fine filament was found connecting the sacral sympathetic ganglia to the plexus on each side. This came from the third sacral ganglion of the sympathetic and was the only connection found passing to the hypogastric and pelvic plexuses from the sacral sympathetic ganglia.

These dissections from a surgical point of view represent the anatomy of the hypogastric nerves and confirm so far as this method permits that a complete sympathetic denervation can be accomplished by removal of this system.

Some variation occurs in the arrangement, but it is an invariable rule that all the fibres forming this nerve become aggregated and plexiform over the fifth lumbar vertebra and promontory of the sacrum, and that if the peritoneum is reflected from the interval between the common iliacs, the

whole of this system—the superior hypogastric plexus of ordinary anatomy —can be removed.

Dissections of the material removed by several different surgeons from this region between the common iliacs show that it is possible to make such surgical exsection anatomically complete. It should be mentioned that Langley found by degeneration methods that a very few fibres of the pelvic nerves (0–4) reach the hypogastric plexus. These nerves are so few that it does not seem necessary to modify any of the previous statements.

The anatomical and physiological aspects of the hypogastric nerve set out above suggest that its removal may be easily accomplished. The removal is carried out at a point where some fibres are still preganglionic, but where most are postganglionic. Our investigations show that a tract of ganglion cells is included in this area. It begins above in the sometimes compact but more often diffuse inferior mesenteric ganglion, and the cells are continued in a more scattered manner in the superior hypogastric plexus. Thus regeneration will not occur.

The point we would make is that in so far as it may be deemed desirable to denervate the pelvic viscera of their sympathetic fibres, this can be accomplished by a retroperitoneal dissection over the fifth lumbar vertebra and promontory of the sacrum between the iliac vessels. Attempts at the removal of the sacral sympathetic ganglia, the lumbar sympathetic chain, or stripping the adventitia from the various blood-vessels entering or within the pelvis, have all been advocated. All these we believe to be unnecessary. The physiological effects of a pelvic sympathectomy can be obtained as stated above. Though we, of course, have been interested in the technique of this operation and the results obtained, we do not propose to discuss these. They, however, do include many cases of pelvic pain, especially in the female, some sexual disorders of the male, some cases of bladder pain and dysfunction.

The innervation of the ureter is in some ways analogous to the innervation of a blood-vessel, in others it resembles the innervation of the gut. A considerable literature has grown up around this matter. Its full discussion would be out of place here. We would present only the main result of our investigation. The ureter gets its nerves from the hypogastric sympathetic system and from the sacral parasympathetic system, and both these reach the ureter near where it enters the bladder. The ureter receives no nerve-fibres along its abdominal or pelvic course other than those which invest and reach it near where it enters the bladder. A plexus of nerves outside and within its muscular coat spreads up the ureter through the whole length of its course from this paravesical plexus.

This arrangement resembles what occurs in the blood-vessels, while the presence of a plexus of double origin with parasympathetic ganglion cells is, of course, an arrangement made familiar by what happens in the case of such viscera as the heart, etc.

The point which emerges from this statement of the anatomy is that, if it is deemed desirable to remove the influence of the sympathetic fibres from the ureter, this can be done by resection of the hypogastric plexus as described for the bladder.

THE SYMPATHETIC INNERVATION OF THE LOWER EXTREMITY.

The observations made on the upper extremity apply in the same degree to the lower extremity. Some degree of permanent vasodilatation most manifest in the foot can be set up by breaking the continuity of the sympathetic fibres to the limb. The most convenient place at which this can be done is in the lumbar sympathetic chain. These chains can easily be reached through the peritoneum, which is stripped back from the aorta. The left chain is beside the aorta, while the right is covered by the inferior vena cava and is easily reached by displacing this vessel inwards. It is sufficient to remove the third and fourth lumbar ganglia with the intervening chain. This operation differs from that in the upper limb, where the connection of preganglionic and postganglionic fibres is actually broken at the stellate ganglion. Thus the removal of the ganglion makes regeneration impossible. In the case of the lower limb the ganglion cells of the third or fourth segments are removed, but all the segments below this level keep their ganglia and postganglionic fibres, the abolition of their physiological effects being due to removing a segment of their preganglionic fibres. Theoretically it is conceivable that regeneration might occur, but it is not likely that the gap caused by the removal of the strip indicated will be bridged.

SUMMARY.

1. Evidence of a general nature has been presented indicating that the sympathetic nervous system is laid down in a way that suggests a particular conformation and a precise anatomy for each region of the body.

2. From a surgical point of view the sympathetic innervation of any particular region can be determined by the method of macroscopic dissection. Innervating fibres that cannot be determined by this method are not of surgical moment.

3. Groups of structures with a certain anatomical homogeneity have a common source of supply of sympathetic fibres, and these have in each case a uniform way of reaching their final distribution.

4. Some physiological conclusions are discussed, and at the moment the most constant and useful result that can certainly be achieved is an increase in the blood-supply to the denervated member.

5. In such anatomical areas a nodal point can be chosen where most conveniently by surgical methods the sympathetic innervation can be broken.

In the case of the head and neck and upper extremity, this interruption is best achieved by removal of the sympathetic chain from the level of the second rib upwards as far as the lateral angle between the vertebral artery and subclavian.

For the large gut, within the distribution of the inferior mesenteric artery, the sympathetic denervation can be achieved by stripping the adventitia widely from the aorta, beginning above the origin of the vessel, going distal to its origin, and continuing on the vessel itself as far as possible, i.e., as far as its first branches. It is, in addition desirable to remove the hypogastric plexus as well.

In the case of the pelvic viscera, including the ureter, a sympathetic denervation can be accomplished by removing the hypogastric plexus.

For the lower extremity, a sympathetic denervation can be most conveniently accomplished by removing the third and fourth lumbar ganglia and the intervening chain.

The work that this paper is based on, and the surgical experience which lies behind it, have been made possible by our association with the Surgical Unit of St. Bartholomew's Hospital Medical College. We wish to thank Professor Gask, the Director of the Unit, who suggested the scope of this contribution and took such a lively interest in its progress.

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MESENTERIC CYST AS A CAUSE OF INTESTINAL OBSTRUCTION.

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THE occurrence of small cysts disseminated over the surface of the mesentery, omentum, and bowel wall is very uncommon. These cysts are placed most abundantly at the bowel margin. They may appear in a small cluster or they may range in large numbers over an extensive area of mesentery.

It is usually during a laparotomy for some entirely separate condition that their presence is casually noted. They may be examined and, inviting puncture, their clear, opaque, or straw-coloured contents are expressed as a watery, chylous, or a thin-jellied fluid. Such rupture would appear to be harmless, but obviously the number of the cysts may negative any consideration of this procedure, or of individual enucleation, being applied to them.

Very rarely indeed these cysts may assume such a prominence as to become the reason for operation, either in virtue of their size, with concomitant pressure embarrassment, or because of some complication in connection with the tumour. The following case therefore justifies its record as a rarity, associated as it is with features which are themselves exceedingly uncommon.

Vera B., aged 8, was admitted to hospital on March 1, 1932. Her parents, one brother, and two sisters were alive and well.

HISTORY.—The patient was normal at birth, and except for measles and troublesome enuresis she had had no illness of any importance. Although apparently healthy, she was reported as being 'difficult' and 'finicky with her food'. She frequently complained of vague pains in the abdomen. For the past year these pains had been becoming more frequent and pronounced. The pains were accompanied by vomiting. Her appetite was affected and she was unable to take food of any description for a day or two at a time.

The child had been ill for six days prior to her admission to hospital. Throughout this period she complained of abdominal pain which was very much more severe than in any previous attack she had experienced. The pain was spasmodic at first but later became more constant. Vomiting was profuse and frequent. There was no normal action of the bowels, and only after two enemata had been given was a small fæcal result obtained.

ON EXAMINATION.—On admission the patient was extremely ill, apathetic, and obviously in pain (circumstances which rendered the interrogation and history both difficult and unreliable). The body was well nourished. The face was pale and at frequent intervals was grimaced with pain. Her breathing was hurried and grunting. The temperature was 99·2° F., pulse 112, respiration 30. Several of the teeth were carious. The tongue was moist and clean, while the fauces were normal. The abdomen was distended but moved freely with respiration. Palpation of the abdomen did not help

to localize the pain, which was vaguely and widely indicated by the child. Tenderness was generalized over the whole abdomen, while rigidity was present in the lower half of the rectus muscles. The abdomen was tympanitic to percussion. A rectal examination was made but nothing abnormal was found. The other systems on examination were found to be normal.

A diagnosis of intestinal obstruction, resulting from a plastic type of tuberculous peritonitis, was made. A plain X-ray of the abdomen (*Fig.* 70)

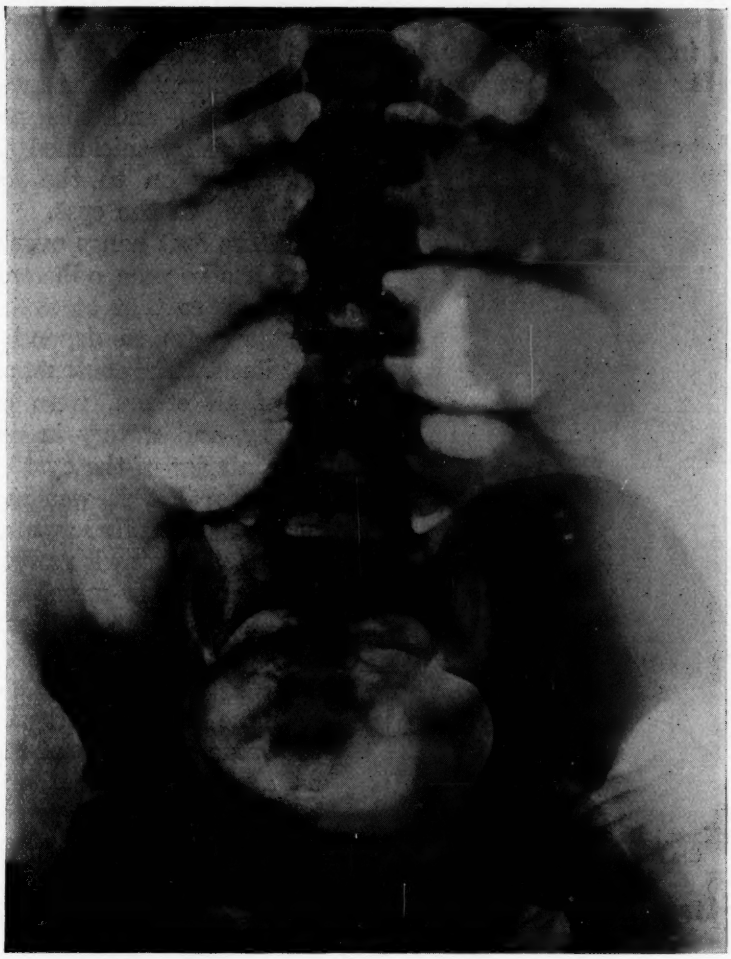

FIG. 70.—Plain radiogram showing marked distension of small intestine.

confirmed the diagnosis of obstruction, and owing to the child's grave condition an immediate operation was undertaken.

OPERATION.—Under spinal anæsthesia combined with gas and oxygen, the abdomen was opened by a right paramedian incision. Distended loops of small intestine were at once displayed. The seat of obstruction was found in the ileum about two feet from the cæcum. Numerous cysts were present throughout the mesentery. One very large cyst had kinked and dragged its weight across the ileum leading to complete obstruction. The cyst and

mesentery, together with two or three inches of bowel on either side of the cyst, were resected and a lateral anastomosis was performed. The abdomen was closed without drainage. The patient made an uneventful recovery and was discharged on March 31.

PATHOLOGICAL REPORT.—On one aspect of the mesentery attached to the piece of bowel, at the attachment to the gut, there are three small thin-walled cysts, the largest being little more than 1 in. in diameter; these cysts are isolated and do not communicate in any way with one another or with the bowel. On the opposite side at the mesenteric attachment is a small cyst about 1 in. in diameter and by the side of it a large cyst about 3 in. in diameter. It proceeds from the mesenteric attachment of the mesentery to the bowel, and this part of its wall is fairly thickened and passes irregularly on to the rest of the thin wall of the cyst.

FIG. 71.—Mesenteric cysts completely occluding the lumen of the ileum.

The cyst hangs over the bowel and has become adherent to it at its side, so that at first sight the cyst appears to depend from the gut itself. The contents of the cyst, as of all others, were clear, pale yellow, and watery in consistence. The interior of the cyst showed no evidence that it was in any way multilocular. There was no connection of this cyst with any depression of the mucous membrane of the gut between the trabeculæ of the muscular coats.

The X-ray photograph shows the value of the use of radiography as a diagnostic method in cases of intestinal obstruction, and even, in some cases, in localizing accurately the site of obstruction.

X-RAY REPORT.—

Abdomen.—The plain radiogram shows five sausage-shaped translucent areas lying one above the other with their long axes transversely across the abdomen. The walls of these gas-filled areas are thin, and in addition fine close-set transverse striations are visible. The gas-filled areas measure 2 in. in diameter. A small translucent area below the left diaphragm is gas in the stomach.

X-ray Diagnosis.—Intestinal obstruction. "The close-set transverse striations indicate valvulæ conniventes and not haustrations, and the distribution of the shadows is that of the small intestine. No cause seen for the obstruction."

The coloured figure (*Fig.* 71), which is an excellent reproduction of the appearance of the cyst and the resected tissue, shows the comparatively

large thin-walled cyst with its broad pedicle merging into the gut wall. Lying in the mesentery, bridging the loop of bowel, are smaller cysts; the one on the left slightly indenting the bowel and acting in counter-pressure to decrease the lumen of the ileum.

The actual site of obstruction is seen above this smaller cyst. The bowel is narrowed to the diameter of a pencil and is discoloured and gangrenous owing to the traction of growth and hanging weight of the large cyst. The proximal loop of ileum is seen congested and distended, while the distal loop is narrowed and collapsed.

The origin of mesenteric cysts is still a matter of controversy. The difference in their size and the disorderliness of their distribution, in relation to anatomical structures, in no way contributes a solution to the problem of their etiology.

As with most rare conditions, their pathology is not clearly understood, and is still further veiled by the general confusion of classification and nomenclature resulting from the changes and vagaries of opinion of those individual pathologists reporting on the few cases that come their way.

The cystic are more common than the solid mesenteric tumours, and are subject to numerous complications, of which intestinal obstruction is by far the most common and serious. Complications such as torsion, impaction, rupture of the cyst, or intracystic hæmorrhage are infrequently encountered.

Intestinal obstruction may arise in various ways, dependent on the size, position, and mobility of the cysts and their situation in the mesentery. The resulting acute obstruction is purely mechanical and is brought about by direct pressure or traction on the bowel, while the occlusion may be completed by adhesions or kinks, or, in very rare instances, by volvulus of the gut. The condition may be considered or suggested by the history, by isolating a mobile cyst, or by the pain, vomiting, diarrhœa, or constipation which arise from the pressure of the cyst. The diagnosis even in uncomplicated cases is notoriously difficult, but in the presence of intestinal obstruction an accurate diagnosis is practically impossible.

I am very much indebted to Dr. Geo. Simon for the assistance given me by his valuable and accurate opinion and for the radiogram reproduced here. I am further indebted to Dr. Teale for furnishing me with the pathological report, and to Mr. Thornton Shiells for the very accurate representation of this rare specimen. The specimen is now in the Museum of the University College Hospital.

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A CASE OF VESICAL PAPILLOMA WITH WIDESPREAD METASTASES.

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It is often difficult to decide whether a vesical papilloma should be regarded as benign or malignant. All stages from completely innocent papilloma to rapidly infiltrating papilliferous carcinoma are seen. A proportion of benign tumours (25 per cent according to Ewing[1]), or their local extensions or recurrences, may sooner or later become malignant.

The malignant villous tumour, however, does not usually spread beyond the bladder before it has killed the patient. If extension does happen, it is nearly always by direct spread to the pelvic tissues, or by the lymphatics to the pre-aortic glands. Distant metastases are rare, and all writers agree that the widespread skeletal deposits, so common in prostatic carcinoma, are almost unknown in vesical carcinoma. With growths that are both macroscopically and microscopically benign extension is confined to deposits within the bladder, unless an incautious operation allows implantation in the abdominal wound.

In the following case the very unusual behaviour of an apparently benign vesical papilloma seems worthy of report.

CASE REPORT.

W. C., age 43, was admitted into St. George's Hospital in April, 1926, having had hæmaturia on and off for a year. Cystoscopy showed extensive papillomata, but hæmorrhage was too profuse for diathermy. Accordingly the bladder was opened suprapubically, one large papilloma was excised, and several smaller ones destroyed with the electric cautery. The patient made a good recovery. After discharge from the hospital he failed to report for cystoscopy in spite of several recurrences of hæmaturia starting from August, 1927. Eventually, in July, 1929, he reappeared on account of pain and swelling of the right knee, noticed for two months, and was admitted.

On Examination.—There was effusion into the right knee-joint, and tenderness over the internal condyle of the right femur. Movements of the joint were painful and limited. There was a scar in the thigh and an irregularity of the lower third of the femur due to compound fracture from a gunshot wound during the Great War. The Wassermann reaction was negative. X-ray photographs revealed no active lesion of the bones, but an old fracture of the distal third of the femur, united with overlapping and backward angulation of the fragments. Cystoscopy showed a very large villous tumour covering the posterior wall of the bladder.

Operation.—On Sept. 9 a papilloma the size of a clenched fist was excised by suprapubic cystotomy.

Subsequent Course.—Healing and recovery of bladder function was uneventful, but the patient remained ill. The right knee became progressively more swollen and painful. X-ray photographs taken on Sept. 19 showed destruction and decalcification of both femur and tibia, with deposition of new periosteal bone. The appearances suggested neoplasm.

On Sept. 24 arthrotomy was performed for diagnosis, and a small piece of tissue removed. The patient's condition deteriorated very rapidly, the tumour of the knee increased, and on Oct. 2 a mass was felt in the right iliac fossa. This also grew very rapidly, even in the short time before his death on Oct. 10, 1929.

POST-MORTEM FINDINGS.—

General Condition.—Wasted. There was a large bony lump on the inner side of the right knee-joint with a healed incision over it. There was a discharging sinus in the suprapubic scar.

Pleuræ, etc.—A few adhesions were present on the left side. On the sixth right rib near its vertebral attachment there was a lump the size of a pigeon's egg.

Lungs.—The right lung was normal. In the apex of the left lower lobe there was a node of growth the size of an orange.

Heart and Pericardium.—The pericardium was normal. The heart was small and atrophic, showing brown atrophy.

Abdomen.—No peritoneal exudate. A large swelling in the right iliac fossa stretched the iliacus and psoas muscles into a thin sheet over it. The ureter and the anterior crural nerve were also stretched on its surface. The mass, which was apparently arising from the ilium, was about the size of a coconut, and, on section, contained a quantity of old and new blood-clot, and had a framework of bony spicules. It extended into the gluteal region through the crest and blade of the ilium, which were completely destroyed.

Liver, Spleen, and Pancreas.—These organs were healthy.

Kidneys.—Both were congested. The right contained some small yellow calculi, but was otherwise healthy.

Bladder.—Contained thick yellow pus. The wall was inflamed and congested, but there was no sign of neoplasm.

Alimentary Tract.—Healthy.

Right Femur.—There was an old united fracture of the lower third. On the outer side of the bone at the junction of the upper and middle thirds, and again at the junction of the lower and middle thirds were two similar

FIG. 72.—The bones of the right knee-joint, showing deposits of growth (A) and an old united fracture (B). (× ½.)

oval masses, about the size and shape of half a hen's egg. Their surfaces were roughened, and their consistency varied, being bony hard and soft in different parts.

FIG. 73.—The right hip and pelvis, showing mass in iliac fossa (A), and deposit in femur (B). (× ½.)

There was no lesion of the knee-joint itself, but there was a mass of fleshy growth involving the lower end of the femur and the upper end of the tibia lying beneath the internal lateral ligament. (*Figs.* 72, 73.)

MICROSCOPICAL FINDINGS.—

1. Sections of the tumour removed in 1926 showed (according to the report made at the time) a typical vesical papilloma with no evidence of malignancy. These sections are unfortunately not now available.

2. Sections of the tumour removed from the bladder on Sept. 9, 1929, show a transitional-cell papilloma. The arrangement is a little irregular, but there is no sign of invasion of the deeper layers, and the individual cells are of uniform shape and size, and show no mitosis. (*Fig.* 74.)

3. Sections of the tissue removed from the right knee on Sept. 24, 1929, show a transitional-cell papilloma exactly similar to the one from the bladder.

FIG. 74.—Photograph of a section of the tumour removed from the bladder in September, 1929, to show the general innocent arrangement. Note the absence of infiltration of muscular coat. (× 3).

FIG. 75.—Microphotograph of section of tumour from the ilium showing papillary processes in a bony framework. (× 50).

4. Sections of tissue removed post mortem :—

a. Bladder.—Sections of the bladder wall in the region of the removed tumour show no evidence of neoplasm whatever.

b. Lung, Rib, Pelvis, Femur, and Tibia.—Sections of the tumours of these organs all show a similar microscopical picture, that of a transitional-cell papilloma. Regular papillary processes form the bulk of the tumour in each case, the individual cells are regular in shape and size, and mitosis is absent. Ossification is evident in the sections from the bony tumours. (*Fig.* 75.)

DISCUSSION.

The following points suggest that the tumour in this case was what is usually regarded as the innocent type of vesical papilloma :—

1. Macroscopic appearance.

2. Multiplicity. It is generally held that tumours which are early multiple do not invade the bladder wall, although they may recur or extend on its lining with great rapidity.

3. Reaction to treatment. If a malignant papilloma is inadequately treated, recurrence is usually rapid and obviously carcinomatous. Yet, after local excision and cauterization in 1926 there was an interval of fifteen months

before any symptoms recurred, and the tumour excised in 1929 was single and non-infiltrating. A month after this, at post-mortem, no neoplasm could be found in the bladder wall.

4. Histology. It is notoriously difficult to be certain of the innocence of vesical papillomas by microscopy, but the appearances were entirely benign on both occasions.

On the other hand, wide dissemination by the blood-stream is so rare a complication of vesical carcinoma that it alone can hardly be held to denote a change in the character of the tumour. According to Colston,[2] metastasis to bones does rarely happen in bladder cancer, the bones of the pelvis and lower spine being early extensively involved. Operation or other therapeutic agencies (such as radium) may result in extensive and widespread metastases from a tumour which has shown no prior evidence of implantation. This, he holds, illustrates the fact, long recognized, that bits of benign papilloma, transplanted, always become malignant and infiltrate extensively. In the case under discussion, although the growth of the deposits was remarkably rapid and destructive, their microscopic picture, like that of the parent tumour, was not one of carcinoma.

It is certain anyway that cells gained access to the blood-stream, and it is of interest to consider when and how they did so. There are objections to the theory that they were introduced at either of the suprapubic operations. If at the first, it has to be explained why the growth of the emboli should have become suddenly and fatally accelerated after quiescence for three years. It is more reasonable to blame the second cystotomy for the events which so rapidly followed it, but some explanation must then be found for the pain and swelling of the knee which preceded this operation by two months, and for which no cause other than neoplasm was discovered either ante or post mortem. On the whole we must conclude that tumour cells entered the circulation independently of operation, from the recurrent growth some months before the patient was admitted to the Hospital in July, 1929.

It is difficult to understand how this could happen in a papilloma unless some few cells at least had lost their innocent nature. Possibly a fairly large vein of the tumour pedicle was eroded and gave them entry. The whole picture here resembles some cases of multiple thyroid metastases, and, as pointed out by Dunhill,[3] malignant adenoma of the thyroid may erode blood-vessels and give rise to distant metastases early in its career, when it is small and confined to its capsule, and thus clinically benign.

According to Young,[4] villous growths of the bladder have produced metastases by the blood-stream when apparently benign, but I have been unable to find the record of a comparable case.

I wish to thank Mr. C. H. S. Frankau and Mr. G. R. E. Colquhoun, under whose care this patient was, for permission to record the case.

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THE SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM.

(The Bradshaw Lecture, delivered before the Royal College of Surgeons of England, December, 1932.).

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Fifty years ago, on Dec. 13, 1882, Sir James Paget delivered the first Bradshaw Lecture in this theatre. Before beginning his lecture he paid a graceful tribute to William Wood Bradshaw, a Fellow of this College, in whose memory the lecture was founded by his widow. Paget took as the title of his paper, "Some New and Rare Diseases". I do not wish to comment on the subject-matter of the paper, but it is an appropriate time to recall some of his remarks, which seem almost prophetic, concerning our Museum and College.

You will remember that Paget gave devoted service to our Museum and that he believed whole-heartedly in its value as a source of study and a stimulus to research. This is what he said fifty years ago[1]: "I feel that the collection is one which all we members of the College may feel personal pride in calling our own, and should feel a personal duty to enrich. And its utility is being constantly more appreciated. I have often been made happy by the contrast which I have seen while working at the new edition of the catalogue. While I was writing the last edition, between thirty and forty years ago, scarcely a student ever entered the museum. Hour after hour I sat alone. I seemed to be working for no one but myself, or for nothing but the general propriety that a museum ought to have a catalogue, though no one might ever care to study from it. Now, and for some years past, a day rarely passes without many pupils and others being at work in every part of the museum.

"All this is good, but much more is to be done. Our museum should be, even more than it is, the centre in which all pathologists may find help in searches after that which is not yet known. For many years, even from the beginning, the anatomical and physiological departments of our museum have been not only a noble collection of specimens, but through the renown and learning of its conservator, a great centre of teaching."

Paget evidently had firmly in his mind the idea that this College should be more than a storehouse of dry bones and a vast collection of bottled specimens. He believed that it should be an active centre for the advancement of surgical knowledge and an inspiration to all those who seek "after that which is not yet known". This dream of Paget's seems to be coming true. The workrooms are now full. A number of promising young men are busily engaged in various problems under the direction of our beloved Conservator. Through the influence of our late President, Lord Moynihan,

the College has been enriched by a number of research scholarships. And lastly, through the great-hearted and far-sighted action of one of our senior Fellows, we have become the owners of the Buckston Browne Research Farm, with its laboratories for Surgical and Biological Research and Education.

Paget surely would have been pleased with these great developments, but he was not the only one who had the idea. The scheme originated, we may believe, in the fertile brain of John Hunter, the creator of the Museum. Hunter did not collect his specimens out of idle curiosity. The collection was not the real object of his work, the museum was the storehouse or reference library, while the workroom was his study. As Trotter said in his Hunterian Oration, the greatness of Hunter lay in his foundation of a school, and he laid the foundation perhaps better and more truly than he knew, for his influence is still felt and is as active to-day as it ever was.

The fifty years which have elapsed since Paget gave the first Bradshaw Lecture have witnessed the greatest advances in surgery the world has ever known. Discovery has followed discovery, and progress has been so rapid that we may be justified in saying that we are living now in the Golden Age of Medicine. In surgery these advances have been made possible by the work of Pasteur, amplified by Lister, himself a Bradshaw Lecturer in 1887, who, as Lord Moynihan once said, made operations safe for humanity.

If one analyses the advances that have been made, it is evident that following the introduction of asepsis, they have been largely due to developments of instruments and of methods of examination, and by these means to improvements of technique, so that little by little every region of the body has become accessible to surgery. This is a part of the truth only, for the development of a safe technique has enabled surgeons to gather much valuable information concerning the early stages of pathological processes, whereas previously they had to rely on the end-results as revealed in the autopsy chamber.

So much for the past. What of the present and of the future? If one reads the portents correctly, there is evidence that a change is coming over the art of surgery. It is becoming less of a craft and more of a science. The minds of surgeons are showing a leaning towards physiology, and surgery is becoming less extirpatory, more conservative and preventive. In other words, the operating-theatre is no longer only a place for the safe removal of diseased organs; it is becoming a scientific laboratory.

This young growth of preventive surgery should be fostered, and it is for this reason that I am taking as the subject of this lecture the surgery of the sympathetic nervous system. It is a vastly intriguing study, for not only is it opening up a new field for surgery, but it is also playing an important part in unravelling the mystery of the anatomy and physiology of this intricate system.

This subject, though still young, has already accumulated round it a mass of literature, and you may expect me to give you a conspectus of all the work that has been done and the history of the workers. It is quite impossible to attempt it in the scope of this lecture, and the reader is thereby spared an impressive bibliography. The endeavour of this lecture is to set out a straightforward narrative of the work that my colleagues and I of the

Surgical Unit of St. Bartholomew's Hospital have done, to tell you our experiences, and to show you some of the results. To attempt a record of my indebtedness to other writers would take too long; let it suffice to say that my creditors are too many to mention and the liability beyond my discharge. Yet I must take this opportunity of expressing how much I owe to the staff of the Surgical Unit and to the Departments of Medicine, Anatomy, and Physiology, without whose help this work could not have been done.

PERI-ARTERIAL SYMPATHECTOMY.

Our first adventure into this new field of surgery was an operation known as peri-arterial sympathectomy. We were incited to this by the example of Leriche, who was made an Honorary Fellow of this College in 1927. Leriche assumed the mantle of his master, Jaboulay, to whom much credit for initiating the work must be given. It is to be regretted that his promising life was brought to a premature close as the result of a railway accident. I cannot help referring also to one Englishman—Alexander, of Liverpool, probably the pioneer of all surgery of the sympathetic nervous system. His work received scant attention at the time, but it is bearing fruit now.

The first peri-arterial sympathectomy done by us was in 1924 on a patient with one blue foot which was associated with great pain. This man had a three years' history of progressive and disabling pain in the right foot. While he was lying in bed both legs appeared normal, except that in the right leg neither the posterior tibial nor the dorsalis pedis artery could be felt pulsating, while those in the left foot could. On standing or walking the right foot and ankle became intensely blue and painful, but on lying down they quickly resumed their normal colour. The condition was then diagnosed as 'endarteritis obliterans hebraica', though in the light of our present knowledge this must be regarded as incorrect. It might be more correctly named 'acro-cyanosis', which again is only a name given to a condition of the pathology of which we are ignorant.

One inch of the adventitia was stripped off the right femoral artery in Scarpa's triangle. Immediately after the operation the right leg became palpably warmer, and the patient was cured of his complaint, was able to return to his work, and has not had any return of his trouble up to the present time (1932).

Unfortunately we have never been able to state with any accuracy what disease the patient was suffering from. It looked as if he suffered from a spasmodic constriction of the arterial supply of the foot, and that this constriction was released by division of the vasoconstrictor sympathetic nerves, which at that time we presumed (though we know now erroneously) to be running down the limb in the outer coat of the femoral artery.

Encouraged by this promising start, a series of patients were treated by peri-arterial sympathectomy, or by stripping the main artery of its adventitia (a more correct description of the operation). The patients thus treated were afflicted, some with incipient gangrene due to arterial degeneration with occlusion of the lumen, some with endarteritis obliterans, and others with

painful stumps (causalgia). In none of these patients, excepting those with painful stumps, was any result achieved at all comparable to the first case described above. A description of these patients has already been published.[2]

This form of operation was then discontinued, because we came to the conclusion that it was based on a wrong premise. We had thought that the vasoconstrictor fibres supplying the vessels of the lower limbs came from the abdominal plexus and ran down the vessels to their termination, and that stripping their coats divided these fibres which are invisible to the naked eye. Gaskell and Langley many years ago proved that in the cat the vasoconstrictor nerves are carried to the blood-vessels via the peripheral systemic nerve trunks. Now Woollard[3] showed, conclusively in our opinion, that in man also the vasoconstrictor fibres reach the arteries of the extremities by the peripheral motor and sensory nerves and not as we had imagined originally, and that we must look for some other means to effect our purpose.

Though this operation of stripping the systemic vessels of their outer coat (peri-arterial sympathectomy) has fallen into disrepute and mostly been abandoned, it is worth while remembering that from its use some small pieces of information have been gleaned, and while at the moment we do not fully understand their import they may later furnish a clue in the final *dénouement* of an intricate puzzle. Sir Thomas Lewis, when shown these patients, said, "You have certainly done something, though I do not know what." We think, therefore, that they are worth recording.

The points which were noticed in almost all the patients treated by peri-arterial sympathectomy were these :—

Firstly, the operation was followed by a rise of temperature of a degree or two in the affected limb. This rise was temporary only, disappearing after a few days or a few weeks. It was supposed at first that this rise of temperature was due to division of the vasoconstrictor fibres, which allowed dilatation of the peripheral vessel and consequent increased arterial flow. As stated above, this view must now be held to be erroneous and another explanation sought. We do not offer any ; we merely record the fact. The second point we noticed was that the operation was followed by a rise in the leucocyte count in the blood from the affected limb as compared with the opposite limb. Many criticisms may be levelled at this observation, but it has been noticed by others, notably by Leriche. The third point noticed, and one which may still justify the continued use of the operation, was relief of pain. This is an important point, but very difficult to explain on physiological grounds. We know that the blood-vessels are sensitive and that painful sensations originating in arteries reach the brain, but we have no knowledge of the path by which they travel. Because a peri-arterial sympathectomy has in some instances been followed by relief of pain, it has been suggested that afferent sympathetic fibres run up the sheath of the big vessels to the abdominal plexus and thence through the sympathetic trunk to the spinal cord and so to the brain. This is mere supposition and is not based on anatomical or physiological evidence.

One further point of histological and perhaps of clinical interest may also be noticed. In some cases of long-standing vascular disease it was observed that gross changes were sometimes met with in the external coat

of the vessels. These changes consisted in great thickening and vascularization of the adventitia, so much so that this coat appeared to the naked eye as flecked with red patches. On microscopical examination it was seen that the external coat was permeated with small vessels, and there were present also numbers of giant cells, giving the impression that the external coat had been the subject of long-standing inflammation.

It now became evident, in view of our better knowledge of the anatomy of the nerve-supply of the peripheral vessels, that if we desired to secure the sympathetic denervation of a limb, the plan of operation had to be altered. To secure complete sympathetic denervation of the vessels of an extremity it is necessary either to cut all the grey rami through which the sympathetic fibres reach the peripheral nerves which send branches to the blood-vessels, or else to extirpate the corresponding part of the sympathetic trunk.

Anatomy.—May I break off from my story a moment to refresh our minds as to the general make-up of the sympathetic nervous system and to show how the vasoconstrictor fibres reach the blood-vessels?

The sympathetic nerves, which are linked on to the cerebrospinal nervous system, are distributed to the internal viscera, to the heart, the blood-vessels, and to the unstriped muscles of the body. For convenience this great sympathetic system, which has innumerable links with the cerebrospinal nerves, is divided into two main groups: (1) The two principal ganglionated cords; (2) The great prevertebral plexuses from which issue the efferent sympathetic fibres which are distributed to the viscera.

Though one talks of the sympathetic system as having an entity of its own, it is very important to remember that it is a part only of the nervous mechanism, and, as Bayliss says, "The sympathetic system is not an independent system, but an outflow of efferent fibres from particular regions of the central nervous system"; it is supplementary to and co-ordinated with the central nervous system.

It is interesting to speculate on the origin of the sympathetic system and to compare it with the nervous system of the lower animals. One cannot do more here than mention that in the more primitive animals, such as the worms and the cockroach, the nervous system lies on the ventral surface of the body, and not, as in vertebrates, on the dorsal side. In which period of the development of animal life the change over from a ventral nervous system to the dorsal system of the higher animals occurred is not known. It has been suggested that the sympathetic system of man represents the primitive nervous system of lowly animals, and that our dorsal nervous system of vertebrates has been grafted on to it. I am not qualified to express an opinion. All I can say is that modern anatomists tell me that there is no foundation for this suggestion.

The foundation of the sympathetic system lies in a number of small medullated nerves which take origin from cells in the lateral horns of the spinal cord, and travel through the anterior roots of the spinal nerves and enter the sympathetic system by slender white communicating rami, to terminate in synaptic relation with the nerve-cells found in the sympathetic ganglia. These communicating cords are the white rami communicantes, or, as they are more commonly called, the preganglionic fibres. These cells are

now believed to be governed by centres in the base of the brain, in the lateral horn of the spinal cord, close to the hypothalamus, and it is thought that a tract of fibres connects these centres with the ganglia in the lateral horns. Demonstrations in substantiation of this point were given this year in this College by Sir Charles Ballance and Professor Beattie.

The proper sympathetic or postganglionic fibres, mostly non-medullated, arise from the cells in the sympathetic ganglia. These fibres run in two ways: (1) From the ganglia to the cerebrospinal nerves, these communicating cords being called the grey rami; (2) To the various plexuses, whence they are distributed to the viscera.

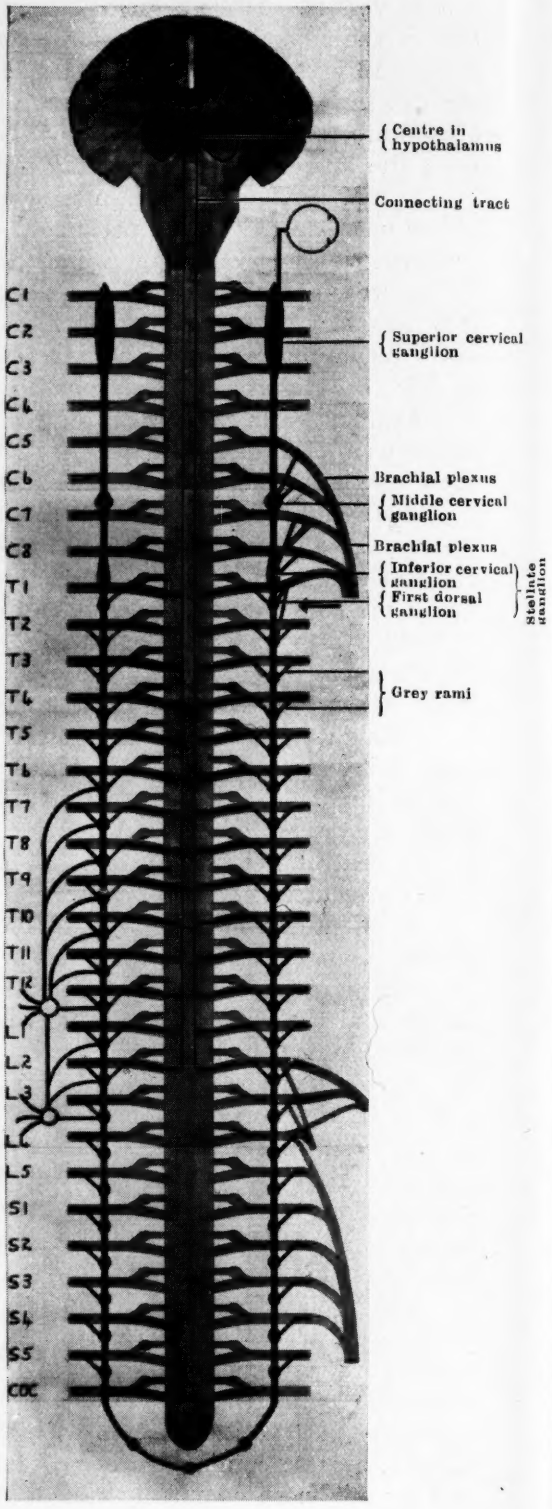

FIG. 76.—Diagram to show the sympathetic outflow in man.

The great ganglionated cords are two in number and consist of a series of ganglia with short intervening chains. These ganglionated cords extend from the base of the skull to the coccyx. The ganglia are nearly equal in number to the vertebræ except in the cervical region, where there are only three. The ganglia are severally connected with the anterior divisions of the spinal nerves by: (1) The white rami, which are composed of medullated fibres flowing out of the spinal nerves into the sympathetic ganglia—that is to say, preganglionic fibres; (2) The grey rami, composed of non-medullated fibres which are the sympathetic fibres passing from the sympathetic ganglia into the cerebrospinal nerves, and are called postganglionic. It is in these fibres that we are interested at the moment, and in them are

contained not only the vasoconstrictor fibres, but also sympathetic fibres to the sweat glands, hair muscles, and the eye.

As shown by Gaskell, white rami communicantes are not furnished by all the spinal nerves. They are given off by the spinal nerves from the second dorsal to the second lumbar nerves inclusive. There is no direct outflow of sympathetic impulses from the spinal cord into the first dorsal nerve, the eight cervical nerves, the lower three lumbar nerves, and the sacral nerves. Consequently the three cervical sympathetic ganglia must receive their branches from thoracic segments of the spinal cord.

Though there are no white rami to the cervical and first dorsal nerves, they get their sympathetic fibres, but not in a segmental way. The majority of the preganglionic fibres turn either up or down in the sympathetic chain, and run for varying distances within it before ending in the ganglia. The cervical sympathetic trunk is composed entirely of sympathetic fibres, coming from the spinal cord, through the white rami of the upper thoracic spinal nerves, and ascending to terminate in the cervical sympathetic ganglia.

These are important facts to remember when considering possible operations for the relief of conditions primarily due to vasoconstriction, such as Raynaud's disease.

The tracts of the sympathetic fibres within the spinal cord and their connection with the base of the brain, and the central mechanisms concerned in the control of nerve impulses through the preganglionic sympathetic neurones, do not fall within the scope of this paper. They are indicated in the diagram (*Fig.* 76). Their anatomy and physiology are the subject of hard work at the present time by various observers, and we may hope to hear more of this before long.

After this digression into the anatomy of the sympathetic nervous system, I will now return to the story.

We have reached the point where we had realized that peri-arterial sympathectomy, though it accomplished something, did not yield the desired results, and further that anatomists and physiologists had convinced us that in order to effect a sympathetic denervation of peripheral arteries it would be necessary to cut off the sympathetic supply at its source. That is to say, it would be necessary to divide the grey rami, through which the sympathetic fibres reach the nerves sending branches to the vessels, or else to extirpate the corresponding portion of the sympathetic trunk.

The work of Jonnesco, of Bruning, of Hunter and Royle, of Adson and Brown, and others, had stimulated interest in this form of surgery. We, in our hospital, under the guidance and stimulus of Professor Woollard, were now induced to abandon the pursuit of the operation of peri-arterial sympathectomy and to seek to denervate the peripheral blood-vessels by dividing the sympathetic fibres in the neck.

In the first instance, Professor Woollard set us the task of dividing the grey rami communicantes passing from the cervical sympathetic ganglia or cord to the fifth, sixth, seventh, and eighth cervical and the first dorsal nerves —that is to say, the cords of the brachial plexus were to be deprived of their sympathetic supply.

Case 1 (A. A.).—The subject was a lady, aged 32, who presented the typical appearances of Raynaud's disease. She had been healthy until the age of 16, when her fingers and toes began to go numb in cold weather, and she began to get whitlows round the tips of the fingers. This condition became progressively worse, and whenever the hands were exposed to cold they became white or mottled blue and white. Some experiments were made by Mr. J. Hunt to see if the 'attacks' of 'cyanosis' could be modified by injecting the nerves of the hand with novocain. Accordingly 3 c.c. of 2½ per cent novocain were injected into the tissues round the left median nerve 2 in. proximal to the distal end of the radius. In half an hour anæsthesia had reached its maximum. An 'attack' was precipitated by exposure of the hand to cold, with the result that the portion of the skin of the hand which was anæsthetized remained warm and red, while the non-anæsthetized area became dark blue. A few days later a control experiment was done on the same hand, only this time sterile water was injected round the median nerve instead of novocain. An 'attack' was again precipitated by plunging the hand in water at 55° F., and in a few minutes the whole hand became blue. These experiments seemed to indicate that the vasoconstrictor nerves run in the systemic peripheral nerves, and that if they are paralysed by novocain, the constricting impulses which they carry are blocked. This experiment is again confirmation of the work of Woollard, that the sympathetic nerve-fibres reach the vessels of the limbs via the peripheral nerves, and do not accompany them throughout their length in their outer coat.

The operation for dividing the rami communicantes passing to the trunks of the brachial plexus was carried out through a 4 in. incision parallel to the clavicle and ½ in. above it. The scalenus anticus muscle was exposed and the anterior primary division of the 5th cervical nerve isolated, and one ramus communicans torn through with a blunt hook. Next the 6th cervical nerve was isolated and one ramus communicans divided. Three such branches connecting the 7th cervical nerve were divided, and two or three from the 8th cervical and 1st dorsal. Finally, the inferior cervical ganglion was exposed, and the dorsal sympathetic trunk was divided with scissors just below the communication with the 2nd dorsal nerve.

Immediately following this operation the right hand became warm and dry, whereas it had been cold and clammy; the palpebral fissure was smaller on the affected side, and the right pupil was smaller than the left. It was found also that if the two hands were immersed in cold water, the right hand remained pink, while the left hand became blue. In addition the blood-pressure and oscillometer readings were higher on the right than on the left side.

The patient was enormously pleased with the result, and begged that the opposite side might be treated; this was done at a later date.

Case 2 (R. T.).—The second case was that of a lady, aged 38, also the subject of Raynaud's disease, only differing from the first patient in the fact that the 'attacks' of 'cyanosis' could be precipitated either by cold or by emotion, and the 'attacks' caused by emotion could sometimes be cut short by taking a glass of port, or perhaps two, or a cup of hot milk.

An operation was planned on the same lines as in the previous case—namely, with the object of carrying out a cervical ramisectomy on the right side. The cords of the cervical plexus and the rami communicantes to the fifth, sixth, seventh, and eighth cervical and first dorsal nerves were avulsed, and the dorsal sympathetic trunk was severed between the first and second dorsal ganglia.

The result of this operation was not so good as the first. The right pupil became smaller than the left and there was slight enophthalmos, and the right hand became warmer and redder than the left. But the improvement did not persist, and a note taken five months later states that the condition of the right hand is not improved; the fingers of this hand go blue many times a day. The right hand is no whit better than the left. The enophthalmos of the right eye persists, and also the contracted pupil.

We learnt something from this case. The fact that the pupil became small and the palpebral fissure narrow showed without doubt that the sympathetic nerve-supply to the eye had been divided. The fact that the colour of the hand changed but did not persist—the fact that the operation did not fully but only partially achieve the end for which it was planned—indicates that the whole of the sympathetic supply for that upper limb had not been divided.

In order to discover the reason for this failure it is necessary to study again the anatomy of the part. On the accompanying diagram (*Fig.* 76) it will be seen that one communicating sympathetic ramus is depicted passing to each cord of the brachial plexus. In fact these rami are very small, difficult to find, variable, and often several instead of one as shown in the diagram. Therefore, if the surgeon relied on cutting these rami, it would not be unlikely that he would miss some. But we did more than this, for we divided the main sympathetic trunk below the stellate ganglion. We believed that we had divided the whole sympathetic supply to the arm, and yet the result seemed to indicate that this was not so, for vasoconstrictor impulses somehow were still coming through.

There is a reasonable anatomical explanation for this apparent anomaly of success in the first patient dealt with and failure in the second. Kuntz has shown that in 21 out of 48 cadavers a branch from the second thoracic spinal nerve sends a branch to join with the first dorsal nerve, and so it must be conceded that the second dorsal nerve forms a part of the brachial plexus in a fairly high percentage of cases. Sympathetic fibres are found in the branch from the second to the first dorsal nerve. Consequently it must be assumed that whenever this occurs sympathetic fibres may also be conveyed to the brachial plexus. The logical sequence of this argument is that, in order to make sure of securing complete sympathetic denervation of the upper limb it is necessary to divide the main sympathetic trunk *below the second thoracic ganglion.* This explanation also accounts for the fact borne out by clinical experience that extirpation of the inferior cervical or stellate ganglion does not always do away with the vasomotor nerves of the upper limb.

A further explanation for failure after division of the sympathetic trunk has been given—namely, that regeneration of the sympathetic occurs very quickly. This rapid regeneration is stated to occur in cats, and it may be true also for man, and it may account for a recrudescence of symptoms in Raynaud's disease after a period of improvement. This point will be referred to again when the results of treatment are reviewed.

Case 3 (A. A.).—The patient described in *Case* 1 had now come in to have her left hand treated. She was so pleased with the result of the first operation that she begged to have the other side done.

This was considered to be a favourable opportunity to test clinically the correctness of the view that complete sympathetic denervation of the upper limb could be attained by excision of the dorsal sympathetic trunk from below the second dorsal ganglion up to and including the stellate ganglion and without touching the variable and elusive rami communicantes.

An operation was planned and carried out for the purpose. By an incision similar to that previously described the inferior cervical ganglion and the dorsal

sympathetic cord was exposed, and after the second dorsal ganglion had been identified, 1 cm. of the cord was excised above this ganglion.

The result fully justified the view of the anatomists, for the left hand became now warm and dry and the patient was much pleased with the result.

By these steps we were led to the belief that the best operation for the relief of Raynaud's disease was excision of a portion of the thoracic sympathetic trunk from below the second dorsal ganglion up to and including the stellate ganglion—the total length of tissue removed being rather more than an inch. This satisfies the requirements of the anatomists and physiologists, and we felt that removal of such a length of the trunk would not be likely to be followed by regeneration. Of this point we are not quite sure now, as the subsequent history of the patient will show later. At any rate this is the plan which we have adopted and used for all our subsequent patients.

I will now give a brief description of the operative technique and follow with a description of the cases.

TECHNIQUE AND RESULTS OF THORACIC TRUNK SYMPATHECTOMY.

We have adopted the anterior approach through the root of the neck. I am aware that this is opposed to the practice of many excellent surgeons, who prefer the posterior route and who expose the sympathetic trunk by excising a portion of rib. I do not proclaim the anterior route is the only one or the best one, but it is the way we have found successful. What may be

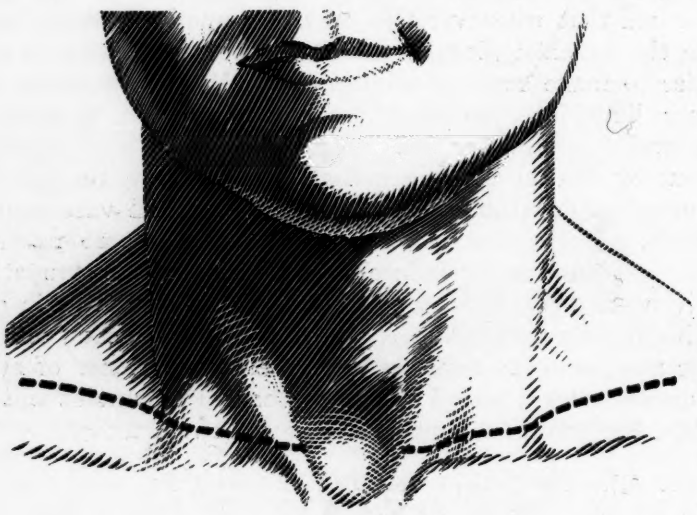

FIG. 77.

said of it is that it is a comparatively simple one, involving a delicate piece of anatomical dissection, though it is not to be recommended unless the surgeon has made himself familiar with the anatomy of the neck by a careful study of the cadaver. Personally I make it a practice to refresh my memory by a visit to the Anatomical Department before each operation. After a little

practice both sides can be done at the same sitting; there is no resection of ribs to be done and no important structure to be divided with the exception of the scalenus anticus muscle.

A 3-in. collar incision is made parallel to and $\frac{1}{2}$ in. above the clavicle (*Fig.* 77). This is deepened through the platysma until the omohyoid muscle is recognized. This muscle is of no importance and is divided and pushed aside. It is a landmark. The next landmark is the scalenus anticus muscle, which is cleared of its covering by a few strokes of the scalpel in the line of its fibres (*Fig.* 78). The phrenic nerve with its fascial covering, lying just anterior to the muscle, is retracted towards the middle line. The scalenus anticus muscle is now divided transversely about $\frac{3}{4}$ in. above its insertion into the scalenus tubercle of the first rib (*Fig.* 79). This is really the key to the operation which makes the subsequent part of the proceedings possible. A retractor is now placed so as to pull the subclavian artery out of harm's way downwards and towards the midline (*Fig.* 80). Then the forefinger of the left hand is pushed along the concavity of the first rib until the articulation of the head of the rib with the first dorsal vertebra is felt. With the forefinger of the right hand the dome of the pleura, together with the fascia covering it, is pushed downwards, and now the sides of the bodies of the first and second dorsal vertebræ are exposed. A

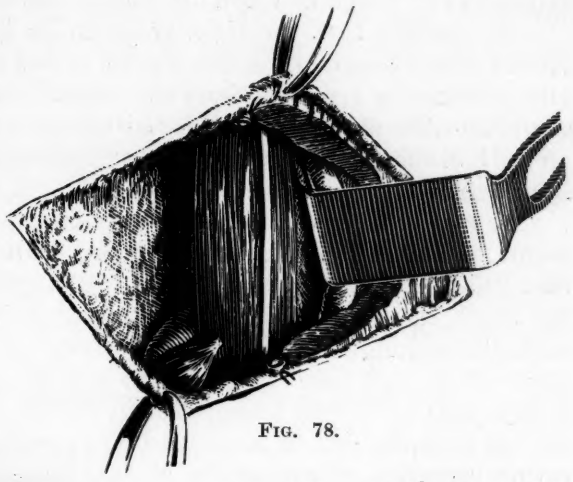

FIG. 78.

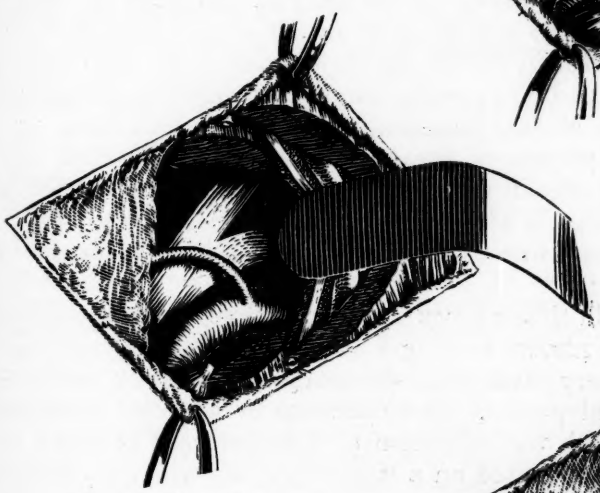

FIG. 79.

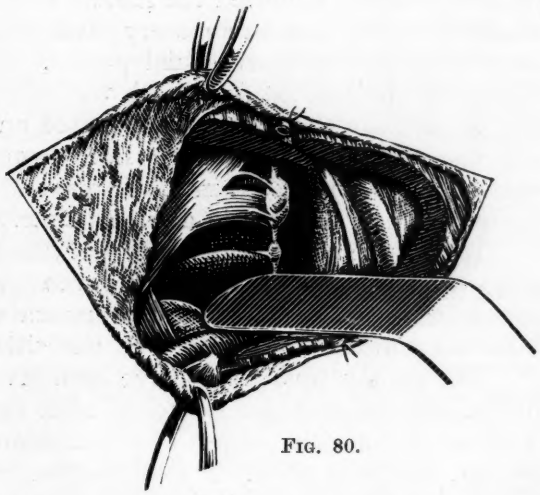

FIG. 80.

good light is needed here as the dissection is deep. The sympathetic trunk lies on the sides of these vertebræ, just medial to the articulations of the ribs with the vertebræ. With the tip of the left forefinger one feels the head of the first rib, and a little blunt dissection of the loose connective tissue lying on the side of the body of the vertebra soon reveals the trunk of the sympathetic, which can now be traced upwards and downwards.

We believe that the right thing to do is to divide the trunk below the second dorsal ganglion, for the reason, as has been stated above, that occasionally a branch is given off from the second dorsal sympathetic ganglion which communicates with the first dorsal spinal nerve. If this branch does exist, and if it is not divided, then some sympathetic impulses may escape from the spinal cord and the beneficial results of the operation may be diminished.

It may be asked, How does one know where to divide the sympathetic trunk? Can the ganglia be recognized with the naked eye? The answer is that it is often difficult to recognize the ganglia with the naked eye, even when the trunk has been dissected out of the body. There is little more than a slight thickening to indicate the position of the ganglia, but with the forefinger of the left hand it is easy to feel the head of the second rib and then with a pair of curved scissors to divide the trunk well below it. The trunk having been divided, it is easy to pull it upwards, to recognize the communicating branches, to expose the stellate ganglion, and to remove it.

The immediate effect of section of the sympathetic trunk is that the pupil becomes contracted, the eyeball sinks back, and the palpebral fissure is narrowed. This pupillary change is a useful test of the success of the operation. If it does not take place, one can safely infer that the sympathetic trunk has not been divided.

The operation conducted in this manner should not have any bad results. On one occasion I injured the pleura, causing a transient pneumothorax, and on another there was a temporary paralysis of the arm due to entirely unnecessary retraction of the brachial plexus. The operation is a pretty piece of dissection and can be done with the minimum of disturbance. In proof of this we can say that lately we operated on a lady of 78, the wife of a doctor and the mother of a doctor. Both sympathetic trunks were divided, the operation was completed in under one and a half hours, and the patient was healed and left hospital in a week's time.

It is time now to make a critical examination of the results of the operations which have been done. Seven patients suffering from Raynaud's disease have been treated in the manner described, four of whom have had bilateral sympathectomy done at one sitting.

The various tests which have been made before operation and the records of the physiological changes found after operation will not be described here. They are to form the subject of a Hunterian Lecture to be given at this College by Mr. Paterson Ross. I shall confine my attention to the results of the treatment on the course of the disease for which the operation was done.

These results may be divided conveniently into immediate and lasting. One can say without hesitation that the immediate results are dramatic and pleasing. Hands, which were previously blue, cold, and clammy, become in a few minutes pink, warm, and dry, and the attacks of cyanosis, often most

distressing to the patient, disappear. These pleasing alterations are accompanied by the characteristic eye changes—namely, contraction of the pupil, slight falling in of the eye, and drooping of the lid. This causes but slight inconvenience and as a rule is not complained of. Of far greater importance are the lasting results. Will the improvement be permanent, and will it hold through cold winters? That is the real test. As will be seen from the scrutiny of our patients, we are not able to guarantee a good permanent result in all cases.

Case 1 (A. A.).—The first patient has already been mentioned. This was a lady of 32, the subject of typical Raynaud's disease. The operation of ramisectomy was done on the right side in May, 1930. She was so pleased with the result that she came back in January, 1931, asking for the left side to be done. The thoracic sympathetic cord was excised on this side.

The immediate results on each side were eminently satisfactory. One is glad to say also that the good results have lasted through two winters. Sometimes the hands go a little blue, but they never become so bad as they were before. She is able to do her housework comfortably and has not had any attacks of cyanosis since the operation.

Case 2 (R. T.).—The second patient has also been mentioned as a partial failure from the start. Her condition was only slightly improved by the operation on the right side, and a few months later both arms were equally bad. She did not come back for a second operation.

We believe that this failure was due to the fact that we did an inefficient operation, by not dividing the sympathetic trunk sufficiently low and thus not securing complete sympathetic denervation of the arm.

Case 3 (E. M.).—The third case was that of a lady of 35, who at the age of 18 began to complain of blueness of the hands on exposure to cold. From the age of 22 the condition became steadily worse, and after the age of 29 changes appeared in the fingers, the nails becoming brittle and the finger tips stubby instead of pointed.

The case was regarded as one of typical Raynaud's disease, but there were in addition two features not present in the preceding cases. The first of these was a tightness and thinness of the skin about the nose and mouth suggesting scleroderma, and the second absorption of the bone of the terminal phalanges, leading to deformity of the tips. These additional features led us to regard the case as an advanced one.

The operation of thoracic sympathectomy was carried out on the right side in February, 1931, and she was so pleased with the result that she asked for the left side to be treated, and this was done in July, 1931. The immediate results were again satisfactory.

The last report, in November, 1932, is that the patient says that last winter the hands were rather better than they had been before the operation. This winter they are about the same, but they are distinctly blue and cold. The condition of the face is definitely improved, the tightness and thinness of the skin has disappeared, and the patient says her face feels warm instead of cold. On the whole she is glad she had the operation done. This may be regarded as a partial success.

Case 4 (M. C.).—The fourth case was that of a draper's assistant, aged 33, who began to suffer at the age of 25 and since then had been going from bad to worse. Both hands and feet were affected, though the hands were worse. Attacks of asphyxia and cyanosis were of daily occurrence even during the warm weather. The condition was so bad that she had to give up her work. This patient was regarded as an advanced case, and additional evidence to this effect was given by the fact that on the left side the radial pulse was barely palpable.

By this time we felt that sufficient experience had been gained to justify doing

both sides of the neck at one sitting. The same route was followed as has been described previously. On Oct. 20, 1931, the sympathetic trunk was divided below the second dorsal ganglion and a portion of the trunk excised up to and including the inferior cervical ganglion. In this instance I was unable with the naked eye to identify the second dorsal ganglion, and felt uncertain at first whether it had been removed. Examination of the part removed showed indubitably, however, that the cord had been severed where planned and that the second dorsal ganglion had been removed.

After operation the patient returned to the ward with both hands warm and pink, and the radial pulse, which previously could not be felt, was now easily palpable. She left the hospital in fourteen days' time well content with the result. In May, 1932, a bilateral lumbar sympathectomy was done to improve the condition of her feet, which were troubling her but had never been so bad as her hands.

The subsequent history of this patient is not good. It is sad to have to tell that the result has not been lasting. She was well during the summer of 1932 and was able to do her work as a draper's assistant, but with the onset of the cold weather in November, 1932, she relapsed; she has been compelled to give up her work as her hands are as bad as they were before. All one can say is that the feet, which prior to the lumbar sympathectomy were always cold, now give no trouble.

Case 5 (B. C.).—The fifth case was that of a married woman who said she had suffered since childhood from chilblains. Fourteen years ago she said she had a severe shock due to a bad post-partum hæmorrhage at the time of an air raid. Since that time she suffered from spasmodic attacks, in which the fingers, and to a lesser extent the toes, became first blue and then white and insensitive. She also complained of sores about the finger-tips which took a long time to heal.

Bilateral thoracic sympathectomy was done on her in November, 1931, the operation being the same as described in the last patient. This patient left hospital eight days after the operation, completely relieved of all her symptoms.

The last report, in November, 1932, is that the hands were perfect until the spring of 1932, when the fingers began to go blue again. Since the cold weather started last November the blueness and whiteness have increased, especially on the left side. The patient is able to do her work, and says she has nothing like as much pain in her hands as before the operation.

Case 6 (L. C. W.).—The next patient was diagnosed as suffering from Raynaud's disease, though admittedly it could not be described as a typical case. In the first place she was a lady of 78 who first began to complain of symptoms only nine months before her operation. Her chief complaints were that her hands were never warm, and that she had great pain in the arms and hands at night, burning sensations spreading from the elbow to the tips of the fingers. There was no evidence of any marked degree of arteriosclerosis and no other symptoms.

Owing to the difficulty of diagnosis I was reluctant to operate, and only did so at the urgent request of her husband, a very experienced physician, who was convinced that an attempt should be made to relieve the pain, which had become intolerable.

Bilateral thoracic sympathectomy was performed in June, 1932. The operation caused little disturbance. It was completed in one and a half hours, and the patient was able to leave hospital after eleven days.

The immediate result was good. The hands were warm, and while in hospital there were no further attacks of pain. At the end of five months after operation the patient's husband writes to me: "Emphatically she is improved as the result of the operation. She never has nocturnal pains nor any diurnal as before operation. There is never need to warm spoons and forks as was the case."

Case 7 (M. M.).—The seventh and last case of this series is a very interesting one. It is that of a lady of 34 who at the age of 22 began to suffer from 'chilblains', and in 1930 experienced attacks of blueness and numbness of the hands. In 1931 these attacks were more frequent, coming on in the summer as well as in the winter.

In September of 1932 a peri-arterial sympathectomy was done on the left brachial artery in a hospital in Scotland, without the least sign of improvement. When we saw her two months ago she presented the typical signs of Raynaud's disease. Attacks of cyanosis affected both hands, and the attacks could be precipitated by emotion or by immersion of the hands in cold water. There was no radial pulse on the left side, and the left hand was rather worse than the right.

Here was a chance to test the truth of the belief that the sympathetic vasoconstrictor fibres run to the peripheral vessels via the peripheral nerve-trunks and not in the adventitia of the big vessels. Accordingly a manœuvre was devised to demonstrate this point. An attack of cyanosis was precipitated by immersion of the hand in cold water, and while the hands were still blue the median nerve at the wrist was infiltrated with novocain. As the brachial artery had been stripped, if the vasoconstrictor nerves were taking the route of the artery then cocainization of the median nerve should have no effect on the vascularization of the hand. Whereas, if the vasoconstrictor nerves accompanied the peripheral nerves they would be paralysed, then the area of the hand supplied by the median nerve should become pink. The hand was watched with intense interest. In a few moments a faint change was observed, and then in five minutes the area supplied by the median nerve became a bright pink while the rest of the hand remained blue—a remarkable demonstration of the correctness of the statement made by Woollard and others. It was now possible to go a step still further and show that thoracic sympathectomy would secure sympathetic denervation of the limb. The operation was done on both sides and it was satisfactory to note that both hands became pink and warm.

It is too early, seeing that the operation was only done in October, 1932, to say what the late results have been; still, at the end of a month, although the weather has been cold, the good results persist.

ASSESSMENT OF THE RESULTS OF TREATMENT OF RAYNAUD'S DISEASE BY SYMPATHECTOMY.

It may appear presumptuous to attempt to draw deductions from seven cases. It is essential, however, that we should not be carried away by the glamour of a dramatic operation, and a careful analysis should be made of the actual results obtained.

The first point that emerges is that these operations have resulted in a better understanding of the anatomical distribution of the vasoconstrictor nerves. They have served as a confirmation of the work of the anatomists and physiologists. As regards the value of the method in the treatment of Raynaud's disease, it can be said that the immediate results are good. As regards the late results, the same cannot be said without qualification. Some are greatly improved, and others very slightly. The improvement is not of a lasting character in all cases.

The clinical results of sympathectomy in the patients having now been described and the facts as far as we know them having been stated, it is interesting to turn to speculation and wonder what is achieved when the sympathetic is divided. There is not the least evidence that the sympathetic nerves are themselves diseased, and it is clear also from examination of the patients that the disease, whatever it is, is not cured. It has been suggested that some unknown substance in the body, possibly endocrinal in origin, sends messages of a vasoconstrictor character along the conducting nerves and that severance of the nerves prevents the message being delivered. This seems too fanciful to be regarded seriously. It appears to us that the suggestion

made by Sir Thomas Lewis is the most helpful. He thinks that in Raynaud's disease there is some unknown condition which reduces the mean calibre of the small vessels, and that sympathectomy, by abolishing the vasoconstrictor impulses, results in a slight increase in the mean calibre and therefore a better blood-supply. This idea accords with the results of our operations. The future of the operation remains yet to be proved, but, if one may judge by the results obtained, it looks as if the vessels regain their power of constriction after a time and that unless the operation is done at an early stage it will have only limited use.

There is another point which requires elucidation. How do the vessels regain their power of constriction, as they seem to do? One suggestion is that the nerves regenerate quickly. In order to prevent this it might be well to divide the trunk with a cautery instead of with scissors, and this procedure we propose to adopt.

LUMBAR SYMPATHECTOMY.

Having had some success in the treatment of Raynaud's disease by division of the cervical sympathetic trunk, we turned our attention to the condition known as thrombo-angiitis obliterans. While the operation of peri-arterial sympathectomy was in fashion, we did a number of cases without registering any success, and so gave it up.

It does not seem reasonable to expect that a vessel which had already become thrombosed and obliterated could ever become patent and function again, and one would expect that in these conditions a lumbar sympathectomy would not prove useful. We thought, however, that, perhaps, if a lumbar sympathectomy could be done in the early stages of the disease, before occlusion of the vessels had taken place, the resulting dilatation of the arteries might avert gangrene of the limb and save amputation. So far as we have seen, this theory is not founded on fact.

The case we used as a test was that of an Englishman, aged 31, who had had his left leg amputated for typical thrombo-angiitis obliterans three months previous to admission. The patient came to us on account of a feeling in his right leg which reminded him of the feeling which preceded the gangrene in his left leg. The right leg showed but poor circulation, the skin was cold and of a blue tint. The dorsalis pedis and posterior tibial arteries could not be felt, but the popliteal was pulsating.

It is a comparatively simple procedure to denervate the lower limb, as will be seen from the diagram (*Fig.* 76). It is only necessary to excise the second, third, and fourth lumbar sympathetic ganglia with the intervening cord. This was done through a mid-line infra-umbilical, transperitoneal incision. After operation there was a temporary improvement, but then the patient became worse. Gangrene set in a few months later, the leg was amputated, and the man died.

It appears that in a disease like thrombo-angiitis obliterans the trouble is not stopped or even delayed by sympathectomy, and we shall have to look for some better method.

HYPOGASTRIC SYMPATHECTOMY FOR MEGALOCOLON.

We now come to the difficult and dangerous question of removal of the hypogastric sympathetic for disturbances of the colon. I say 'dangerous' deliberately, because there is a risk that if the operation is boomed it might be used indiscriminately and become a fashionable cure for constipation, and so bring the method into disrepute. The greatest care should be taken to record accurately which sympathetic fibres are divided at operation, and this is not always easy to do; and further, the subsequent history of the patients treated should be followed for a sufficient length of time to determine the true value of the treatment.

It will be seen by reference to the diagram that the sympathetic supply to the colon comes from the hypogastric plexus and that this can be removed without touching the lumbar ganglia. The nerve-fibres run in the loose connective tissue on the front of the aorta, and they spread along the course of the inferior mesenteric artery and also down the aorta to the two iliac vessels and into the connective tissue lying between the two iliac vessels in front of the vertebral column. One cannot identify all these branches with the naked eye, therefore the operator should aim to strip all the loose connective tissue off the front of the aorta from an inch above the inferior mesenteric artery, including an inch of that vessel, and then down the aorta to the two iliac arteries, and remove as well the loose connective tissue between them.

We have done the operation three times and the immediate results have been startling and aptly described by Lord Moynihan as too good to be true. I feel we must be very cautious before we accept them as true, for we are not sure as yet whether the results are lasting.

Case 1 (J. I.).—The first patient was a girl of 19, who suffered from constipation, retention of urine, with enormous distension of the colon. She could not remember ever having her bowels open without medicine, and as she grew older she would go days or even weeks without relief. As a child she would pass water only twice daily, and for three months she had to be catheterized, retention being complete. She was treated vigorously by the physicians for a long time and then referred to us as they could not keep her well. Physical examination revealed nothing beyond enormous distension of the colon.

The operation was performed in May, 1930. From the day of operation the patient began to pass her water at regular intervals without difficulty. Enemata and aperients were required until she began to get about again, after which time the bowels acted twice daily without assistance.

Eighteen months later she appeared healthy and of good complexion. Occasionally aperients were necessary, but with care the bowels could be kept regular. Barium enema examination showed that the colon was much less distensible than formerly. One may say without exaggeration that this patient has been greatly improved.

Case 2 (Nurse H.).—The second case was that of a hard-working hospital nurse, who had been through the Great War, and it was only in 1928 (following, in 1921, radium into uterus for menorrhagia; 1922, right oöphorectomy; 1927, subtotal hysterectomy and partial left oöphorectomy) that she noticed that she was becoming constipated and had abdominal distension. The bowels were only opened after large doses of medicines and enemata. She had practically to spend her life getting her bowels open. She had been admitted to Queen Mary's Hospital, Roehampton,

and was discharged as incurable. On the suggestion of Lord Moynihan she was sent to St. Bartholomew's Hospital for sympathectomy.

On admission she was found to be fairly well nourished, and had extreme difficulty in getting her bowels open; they could only be moved by enemata. In addition to that, she could go long periods without the slightest inclination to micturate; frequently she went twenty-four hours. Also, she had found that during the last two years her hands and feet got cold and blueish.

Operation (Nov. 6, 1931): Numerous old adhesions were found between the coil of small intestine and cæcum, cervical stump, and the left ovary, which was cystic. All cellular tissue in the region of the bifurcation of the aorta and one inch of the common iliac artery were dissected away, and all the tissues between the two iliacs down to the shining membrane. The inferior mesenteric artery was identified and all the loose tissue stripped from it for an inch along its course.

The immediate results were most remarkable. The bowels were opened naturally on the second day after operation, and the patient micturated normally. She found herself ever so much better and expressed herself as delighted with the operation.

A year has now passed since the operation, and the patient is still pleased with the result. She is once again able to earn her living and to lead a normal life. With the help of simple laxatives she keeps herself fit.

Case 3 (H. P.).—This was a young girl of 14 who had had trouble in opening her bowels from the day of her birth: she was ten days old before her first action. Ever since she has had trouble, and sometimes six weeks passed without a motion.

At operation, on Nov. 15, 1932, the sigmoid flexure and ascending colon were enormously distended and thickened, assuming the appearance of a conger eel. The sympathetic supply of the colon was removed, as we believe, by the method described above.

So far all is going well, but it is too soon to say more.

As was said before, there is need for caution in assessing the results of these operations. They are still too few and too recent to justify our forming a good opinion. It is generally admitted that the immediate results are good, though why they should be good is a question we cannot answer. Is it the effect of the mind on the body, or does the removal of sympathetic stimuli to the unstriped muscle of the bowel render that organ resilient instead of spastic? Very little is known of the sympathetic supply to the bowel. We do not know if the sympathetic joins the plexuses of Auerbach and Meissner, and the part played by these great plexuses still wants explanation and offers a good field for research.

This brief survey of the surgery of the sympathetic system is admittedly inadequate. It is to be regarded as an adventure into the field of research, rather than as a conquest bearing tribute. As Paget said, it is meant to help in "searches after that which is not yet known", and if in making this contribution others may be incited to probe still deeper into the unknown, I believe that Mrs. Bradshaw, the founder of this lecture, would approve.

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[3] WOOLLARD, H. H., "The Innervation of Blood-vessels", *Heart*, 1926, xiii, No. 4.

PIED FORCÉ OR MARCH FOOT.

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"MANY obscure cases of injury to the foot without any history of traumatism in civil life will no doubt receive elucidation by the new facts brought to light by March Foot."[21] Thirty-four years ago, this sentence concluded an editorial leading article on March Foot, yet the position to-day is not much altered.

The following case report and another from elsewhere[20] show unnecessarily radical treatment for this condition of Pied Forcé or March Foot, and probably even now, although orthopædic surgeons are familiar with it, it is not otherwise widely known and not usually described in the text-books; therefore this note may be justified, in the hope that similar mistakes may be avoided.

CASE REPORT.

Mrs. C. M., aged 51. No family. November, 1930. (Dr. Romanes' patient.)

HISTORY.—There was pain in the fore part of the right foot, centred at the shaft of the second metatarsal; it was aggravated by walking. The patient was in excellent health and had played golf daily until a month previously. She could not recollect any slip, strain, or accident during the several preceding years, either to her feet or other part of her body. Her past illnesses were trivial and not relevant.

ON EXAMINATION.—The patient looked healthy and fit, and weighed about 8½ stones. There was a diffuse patch of tender, painful, solid œdema over the shafts of the metatarsals, more prominent over the second, with a blushing of the skin and a little dilatation of the superficial veins. There was no tenderness on pressure over the spring ligament of the foot, nor of the attachments of the internal lateral ligaments of the knee-joint; no hallux rigidus or valgus; no metatarsalgia or gross callosities. No glands were palpable in the popliteal space or inguinal regions.

X-ray Examination.—Fig. 81 is a skiagram taken by Dr. Rhynland Parry, who reported: "The distal end of the shaft of the second metatarsal shows periosteal reaction perpendicular to the shaft; there is some localized rarefaction. I cannot obtain any history of trauma. The appearances lend suspicion to a new growth (sarcoma)."

FIG. 81.—Mrs. C. M. March Foot (? sarcoma) affecting the second metatarsal shaft. Note the short first metatarsal and the thickening of the shafts of the second and third metatarsals and of the basal phalanges of the third and fourth toes.

Owing to the element of doubt in this report a second opinion was obtained from an independent radiologist, Dr. Claude Gouldesbrough, who reported: "This

case is interesting and difficult; my opinion is that she has had an old united fracture and is now developing a periosteal sarcoma over the old callus which obscures the ordinary diagnostic appearances of new growth. I must admit that there is only a shred of evidence for this."

A month later Dr. Rhynland Parry took another radiograph and repeated his opinion of a probable new growth. Two independent Wassermann reactions were returned negative, thus excluding a syphilitic lesion.

OPERATION.—In view of the suspicious radiological diagnosis of sarcoma, I advised a Lisfranc's amputation; this would eliminate the painful swelling and the possible new growth. I considered a more radical amputation would not materially help the prognosis, whilst local excision of the metatarsal, if it were the seat of a sarcomatous change, would be dangerous owing to the risk of growth implantation in the wound. Accordingly on Dec. 3, 1930, the classical Lisfranc's operation was performed and the patient made an uninterrupted recovery.

FIG. 82.—Microscopic section of second metatarsal. (× 20.)

MACROSCOPIC SECTION. — The considerably thickened metatarsal consisted of dense greyish-pink bone throughout, with evidence of a slight irregular crack in the shaft, but none of localized growth. There was no softening; the whole bone was hard and sawn through with difficulty.

MICROSCOPIC SECTION. — Dr. Arthur Davies reported on the section (*Fig.* 82) as follows: "On the evidence afforded by the microscopic sections examined, I am unable to find signs of a sarcoma. The lesion is, as far as my sections show, a rarefying osteitis with a chronic inflammatory periostitis."

FIG. 83.—Mrs. C. M.'s feet, showing fair appearance after right Lisfranc's amputation. These were the first pair of shoes, after two year's wear; an improved new pair, now being made, will be less noticeable.

POST-OPERATIVE PROGRESS.—The patient was fitted with boots, the front half of the right one being blocked out and fitted with a spring arch support, and she has recovered her walking well. Later she took to shoes similarly fitted, and has resumed her golfing activities during the past year, playing eighteen holes, four or five times a week, with her original handicap of 24 (*Fig.* 83). Her general health is good, and there is no sign of a recurrence either in the foot or radiologically in the chest.

I have come to the conclusion that this is a case of Pied Forcé on the following grounds: (1) The microscopical section; (2) The history of the affection (I think the patient probably developed her fracture through straining her feet at golf, which she played hard); (3) The after-history (it is two and a half years since the tumour was detected, and, had it been malignant, recurrence would now very likely have occurred).

This case is of further interest, showing that a Lisfranc's amputation, although nowadays seldom performed or advised, still has a useful place in surgery, the patient having a sound and presentable foot, able to withstand the strain of ordinary life, whilst being inexpensive and trouble-free to maintain.

THE LITERATURE.

In 1855 Breithaupt[1] described cases of persistently œdematous and painful feet occurring in soldiers, calling it 'Fussgeschwulst', i.e., traumatic inflammation of tendon-sheaths. In 1877 Pauzat,[2] a French author, pointed out its occurrence in soldiers and that there was a marked periosteal proliferation; this latter observation was a clinical one, the help of X-rays not being then available. He further observed that later exostosis developed on the shafts of the second, third, and fourth metatarsals, that of the second being the commonest. In the same year Weisbach,[3] in discussing the same condition, came to the conclusion that it was due to traumatic inflammation of the inter-metatarsal ligaments rather than of the tendons, calling it 'syndesmitis metatarsia'.

In 1888 Poulet[4] concluded that the underlying cause was a rheumatic osteoperiostitis, and he did not agree with Pauzat's theory that it was excited by the transverse crease of the uppers of heavy boots. In 1891 Martin,[5] as a result of seeing 18 cases, decided it was due to synovitis and arthritis of the joints of the fore part of the foot.

In 1897 Busquet[6] wrote a memoir upon ossifying osteoperiostitis of the metatarsals, and he divided them into three classes: (1) Direct primary immediate traumatic periostitis, due to repeated slight shocks in the fore part of the dorsum of the foot, largely owing to the transverse furrow in the upper leather of the shoe; (2) Indirect traumatic periostitis; (3) Diathetic periostitis.

Schulte,[7] studying it this year (1897), recognized the fracture. In the same year Stechow,[8] of the Prussian Guard, at Madrid discussed fracture of the metatarsals as a cause of swollen feet in soldiers. His observations are of considerable historic interest in that they were the first to be studied with the help of the X-rays. He had seen 36 cases. He pointed out that owing to the protrusion of the head of the second metatarsal beyond its

fellows, it consequently received the brunt of the strains exerted on the foot from the sides. Further that: (1) There was a fracture of the shaft of the metatarsals in nearly all cases; (2) The left was affected more frequently than the right. (3) Of 36 fractures, they occurred in the following order of frequency: second metatarsal 19, third metatarsal 14, fourth metatarsal 2, first metatarsal 1.

In February, 1899, Chapotot and Boisson[9] further reviewed the condition. They found that: (1) Crepitation was always present; (2) The second metatarsal was always afflicted in their cases, the third occasionally suffering; (3) The fracture occurred at the junction of the middle and distal thirds; it was V-shaped, with the concavity forward, and never a transverse break; (4) Soldiers could still raise themselves on tip-toe, thus differentiating March Foot from arthritis. As an explanation for its occurrence the writers offered the greater fixity, length, and active function of the second metatarsal, these producing the condition necessary for a lever of the second order on a slender bone. They further said it might arise from arthritis and strains of the metatarsal articulations.

FIG. 84.—A weak but 'uncomplaining' foot showing: (*a*) A somewhat short but hypermobile first metatarsal, with posteriorly placed sesamoids; (*b*) Thickened second and third metatarsal shafts; (*c*) Fracture of the base of first metatarsal (the reason for the X-ray).

Thiele[10] in 1899 studied 17 cases; he met them in three and a half months, all from one battalion.

The numbers of cases during these early years are surprising; the condition was very common amongst soldiers, perhaps owing to their severe and exhausting régime, which would certainly be heavier than in the present day.

Momburg[11] in 1904 believed that the prolonged elastic bending of the metatarsals resulted in an inflammatory reaction which was later followed by fracture. He showed that in 'uncomplaining feet' silent proliferations of the second and third metatarsals were present. *Fig.* 84 shows a similar condition in a patient reporting with a fracture of the base of the first metatarsal.

In 1905 Kirschner[12] decided that all March Feet were due to fracture of the metatarsal shaft, and that the displacement was slight owing to the immobilization of the fragments by the surrounding structures. Further, he believed that the fractures occurred after the muscles supporting the metatarsals (long toe tendons and interossei) were exhausted, so that the strain fell undamped directly on the ligaments and bone. Later, Bähr[13] in 1913 again studied the condition amongst soldiers.

In 1921 Deutschländer[14] described 6 cases in civilians, all women, instead of the usual soldiers. Three of his patients ran a low febrile course, and he illustrated the slow callus formation—eight to nine instead of the usual three to four weeks. He considered that there was a low-grade hæmatogenous infection present, giving rise to a periostitis in the second and third

metatarsals. He remarked on the pain provoked by moving the second or third toes sideways, and pointed out that the site of fracture was that of the entry of the nutrient vessels of the metatarsal shaft (*Fig.* 85).

Sir Robert Jones[15] in 1921 mentioned March Foot, and again with Lovett[16] he refers to it as 'Pied Forcé' in 1923.

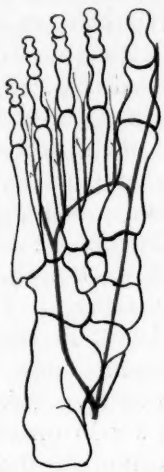

FIG. 85.—Showing the blood-supply of the shafts of the metatarsals. (*After Deutschländer.*)

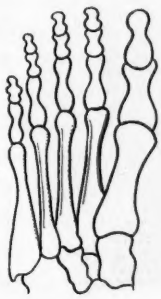

FIG. 86.—The origins of the interossei muscles; note that the second, third, and fourth metatarsals are chiefly concerned. The dotted lines indicate the origins of the three plantar interossei, the continuous lines the origins of the four dorsal interossei.

In 1926 Jansen[17] described 6 cases. He discussed the literature, and offered the explanation that the condition was due to anterior spastic flat-foot, i.e., spasm of the interossei muscles, resulting in œdema with lymph and venous stasis about the metatarsals, especially those where the interossei take origin, i.e., the second, third, and fourth (*Fig.* 86). This spasm of the interossei, denoted by pain and resistance on attempting to move the toes sideways on the head of the metatarsal, was also noted by Deutschländer, but without remark on its significance. Jansen said proliferation of the soft parts and periosteum follow with the laying down of new bone and increased density of the shafts of the second, third, and fourth metatarsals (*Figs.* 81, 87). (The case illustrated by Goldman[19] shows this phenomenon, although he does not point it out; similarly, it is present in my case.)

Later, spindle-shaped formations develop on the metatarsal shafts, and these, Jansen explained by: (1) Callus around the fractures (*Figs.* 81, 87); (2) The organization of subperiosteal hæmorrhages, which readily occur owing to the congested periosteum being easily detached by a strong pull of

FIG. 87.—A 'weak' foot with a hypermobile first metatarsal, showing: (1) March Foot of the third metatarsal; (2) Thickening of the shafts of the basal phalanges of the second and third toes; (3) Thickening of the second and third metatarsals.

the interossei. He emphasized that these changes were located only to the site of the interossei attachments. With regard to this statement, I would point out the slight bulbous enlargements of the shafts of the first phalanges of the second, third, and fourth toes in the case of Mrs. C. (painful flat-foot, with thickening of the shaft of the second metatarsal, *Fig.* 88), also *Figs.* 81, 87, 89. The fluffy swellings on the basal phalanges are at the attachment of the fibro-aponeurotic canals of the long and short flexor tendons of the toes. "These fibrous canals are bounded above by the phalanges and below by fibrous bands which arch across the tendons and are attached on either side to the margins of the phalanges. Opposite the bodies of the proximal and second phalanges, the fibrous bands (vaginal ligaments) are strong and the fibres are transverse" (Gray[18]). This phalangeal thickening suggests unusual strain on these canals, probably from continued spasm of the flexor tendons.

FIG. 88.—Mrs. C. A painful 'weak' foot showing: (1) Thickening of the shafts of the second and third metatarsals; (2) Fluffiness of the shafts of the basal phalanges of the third and fourth toes and of the second slightly; (3) Posteriorly placed sesamoids.

Jansen explains the fracture as follows:—

1. Abnormal and excessive function of the interossei resulting in spasm, produces increased hydrostatic pressure, especially lateral, around the shafts of the metatarsals. This is followed by "absorption of lime salts and thinning out of its constituent parts", with resulting 'brittleness'.

I would point out, however, that the X-rays show no sign of absorption or erosion of the shafts of the metatarsals; on the contrary, they are definitely denser and thickened, but with loss of definition of the lines of architecture or lines of stress (a weakening factor), especially of the second and third (the most frequently affected).

2. With the flattening of the transverse arch the second metatarsal, being longest, is pressed hardest on the ground in walking.

He assumes that there is a transverse arch of the fore part of the foot, but its existence is denied by Morton.

He admits that direct repeated trauma of the second metatarsal may excite the fracture. This trauma is considerable; it amounts to the weight of a man, say 140 lb., with a 90- or even a 110-lb. pack, in all over 2 cwt. This applied weight, plus the power of the 'push off' in walking, is borne by each foot sixty to seventy times a minute whilst marching (120 to 140

FIG. 89.—A 'weak' foot, showing: (1) Hypermobile short first metatarsal (space between first and second cuneiforms and posteriorly placed sesamoids); (2) A compensatory hypertrophy of the second metatarsal; (3) Thickening of the shafts of the second, third, and fourth basal phalanges; (4) Osteo-arthritis of the second metatarso-phalangeal joint.

paces per minute). I think that trauma must play the larger part in producing the fracture, and that the spasm of the interossei is a small contributory factor.

Further, with regard to the site of the fracture, Jansen's theory of spasm of the interossei, whilst not explaining its consistent location to the junction of the middle and distal thirds of the metatarsal, does offer a hint. The congestion around the metatarsals similarly affects their nutrient vessels, and thus causes the vascular foramina to enlarge, so establishing a constant weak spot. The nutrient vessels, according to Deutschländer[14], enter at the distal two-thirds, this being the place where the fracture always occurs.

In 1928 Goldman[19] reported the case of a pedlar aged 29 who developed Pied Forcé in his right foot. He carried an 80-lb. pack on his right shoulder; thus his occupation bears comparison with soldiering. He gave no history of an injury, but for ten days the painful foot had incapacitated him. The X-ray illustration showed: (1) A fracture of the second metatarsal; (2) A mild bulbous enlargement of the shafts of the basal phalanges, second and third toes, and a slight irregularity (? a crack) of the corresponding phalanx of the third toe.

In 1932 F. H. Straus[20] reported a case diagnosed radiologically as a sarcoma of the second metatarsal and sent for amputation. His patient was an obese married woman, aged 30, a waitress, the mother of two children. She complained of pain and a hard tumour of the foot, arising without accident, and the pain increased from pain on effort only, until it was continuous day and night; she lost 13 lb. in seven weeks. X-rays showed a swelling of the second metatarsal shaft at the junction of the middle and distal thirds, with hazy and indistinct margins, whilst the medulla was unchanged. No fracture line was made out. The shaft of the third metatarsal showed thickening and increased density. There is apparently a fracture of the shaft of the first phalanx of the fourth toe, but this is probably an artefact. The second metatarsal was excised; the swelling was hard, but dintable by the finger, and an old fracture was obvious on section of the bone. The microscopical section showed well-developed and partially calcified osteoid tissue, there being no inflammatory reaction. Straus observed that the development of callus becomes painful and attracts attention, and offered the warning that it may be mistaken for a neoplasm and amputation considered, unless March Foot is remembered. This is another instance of unduly radical treatment.

DISCUSSION.

According to the modern conception, the mechanics of the human foot depend on adequately strong and properly balanced muscles of the calf and foot. If these are efficient, then, irrespective of the bony architecture and ligaments of the foot concerned, the patient will probably be able to carry on with his or her occupation satisfactorily. On the other hand, Morton[22] has shown that certain feet function under mechanical disadvantages, being architecturally weak. He describes four signs or defects which can be diagnosed by X-rays, and states that when they are present the potentiality of anterior foot trouble is considerably increased. The signs are:—

1. Laxity of the joint between the internal cuneiform bones and between them and the scaphoid, resulting in hypermobility of the first metatarsal (*see Figs.* 87, 89). This is shown by a distinct separation between the first and second cuneiforms, resembling a backward continuation of the first inter-metatarsal space (*see Figs.* 87, 89).

2. Shortness of the first metatarsal, this causing over-pronation of the foot, i.e., planus of the anterior part of the foot, as the head of the metatarsal is not long enough to reach the ground in the normal attitude (*see Figs.* 81, 89, 90).

3. Posteriorly located sesamoid bones at the head of the first metatarsal, these representing its point of contact with the ground, and when they are

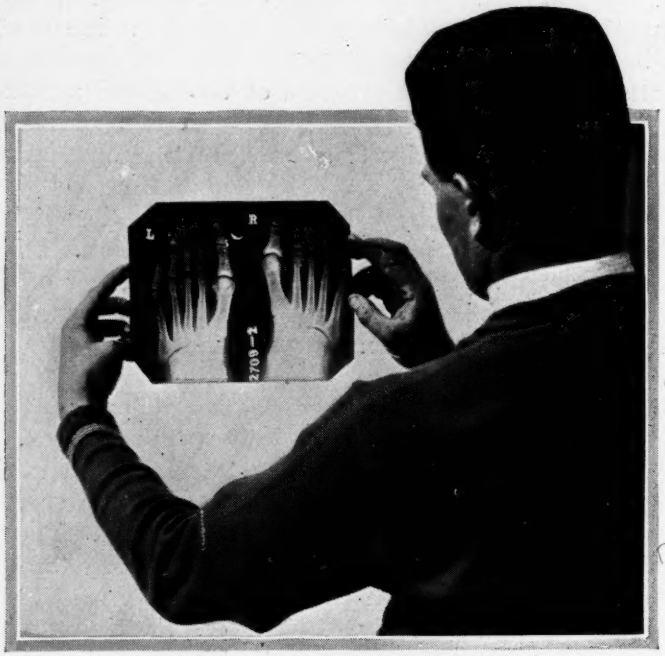

FIG. 90.—"The Ashes winner surveys a part of himself: Larwood with the X-ray photograph of his injured foot."[23] Note (1) the short left first metatarsal, (2) the thickened shaft of the left second metatarsal.

An architecturally 'weak' left foot (Metatarsus atavicus); it gave trouble during the Australian Test Matches.

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posterior to the line of the head of the second metatarsal, they have practically the same effect as that of a short metatarsal, i.e., they prevent adequate weight-bearing by the first metatarsal (*see Fig.* 88).

4. Morton points out a further acquired physiological characteristic resulting from these defects; it is an enlargement of the shaft of the second metatarsal bone, especially in its transverse diameter, arising in response to the increased burden thrown on it by the incompetent first metatarsal (*see Figs.* 81, 87, 89, 90).

I have examined, for Morton's four points, the radiograms of fourteen March Feet illustrated by divers authors, and *Table I* shows their various

Table I.—TABLE SHOWING THE CHARACTERISTICS OF ELEVEN MARC... ...ET.

Table I.—Table Showing the Characteristics of Eleven March Feet.

No.	Case and Location of March Foot	Short 1st Metatarsal	Posteriorly Placed Sesamoids of 1st Metatarsal	Space between 1st and 2nd Cuneiforms	Thickened 2nd Metatarsal	Thickened Outer Border of 1st Metatarsal	Diagnosis re Foot
1	Deutschländer 1. Right 3rd metatarsal	Yes	Yes	Yes	?	Yes	Short and hypermobile 1st metatarsal. Weak foot
2	Deutschländer 2. Right 2nd metatarsal	Yes	Yes	Yes	Yes	Yes	Short and hypermobile 1st metatarsal. Weak foot
3	Jansen 1. Right 2nd and 3rd metatarsal ..	No	Not clear	Not clear	Yes and 3rd metatarsal	Yes	—
4	Jansen 2. Right 2nd metatarsal Left 2nd metatarsal	No No	Not clear Not clear	Yes Yes	Yes Yes	Yes Yes	Hypermobile 1st metatarsal Hypermobile 1st metatarsal
5	Jansen 3. Right 2nd metatarsal Left 2nd metatarsal	No No	Not clear Not clear	Yes Yes	Yes and 3rd and 4th metatarsal Yes and 3rd and 4th metatarsal	Yes Yes	Hypermobile 1st metatarsal Hypermobile 1st metatarsal
6	Jansen 4. Left 3rd metatarsal	No	Yes	Yes	Yes and 3rd metatarsal	Yes	Hypermobile 1st metatarsal
7	Jansen 5. Right 3rd metatarsal Left 2nd and 3rd metatarsal ..	No No	Yes Yes	Yes Yes	Yes and 3rd metatarsal Yes and 3rd metatarsal	Yes Yes	Hypermobile 1st metatarsal Hypermobile 1st metatarsal
8	Straus. Left 2nd metatarsal	No	Yes	Yes	Yes	Yes	Hypermobile 1st metatarsal
9	Goldman. Right 2nd metatarsal	No	Yes	Yes	Yes and 3rd metatarsal	Yes	Hypermobile 1st metatarsal
10	Dodd 1. (*Fig.* 81.) Right 2nd metatarsal	Yes	Yes	No	Yes and 3rd metatarsal	Yes	Short 1st metatarsal
11	Dodd 2. (*Fig.* 87.) Right 3rd metatarsal (Illustrated only)	No	Yes	Yes	Yes and 3rd metatarsal	Yes	Hypermobile 1st metatarsal
	Totals of 14 feet	3 of 14	9 of 9	12 of 13	13 of 13	14 of 14	12 Hypermobile 1st metatarsals 3 Short 1st metatarsals

characteristics. It reveals: (1) Signs of hypermobility of the first metatarsal in 12 out of 13 feet; (2) A short first metatarsal in 3 cases; (3) Posteriorly placed sesamoids in all the cases in which an observation is possible; (4) A thickened second metatarsal in 13 feet, and a similar affection of the third in 7 cases, and of the fourth in 1; (5) Marked increased density of the outer border of the first metatarsal in all cases.

Thus, Pied Forcé is most likely to occur in weak feet architecturally.

I believe that March Foot is a complication of subacute flat-foot occurring in architecturally weak feet. In these, muscular spasm and exhaustion alternate, and, as the latter supervenes, the stout ligaments of the foot are gradually stretched, and direct trauma to the bony skeleton of the foot occurs. These undamped shocks will produce effects in the weakest bones first, and the slender, resilient metatarsals fall into this category.

As the flat-foot develops, the feet take up the usual flat-foot position, pointing outwards, instead of approximately straight forwards. Thus the body weight is no longer carried through a line passing between the first and second metatarsals, parallel to their shafts, and distributed squarely on to the five heads of the metatarsals, but falls largely in an oblique direction on the inside of the foot, i.e., on the first most (if it is normal), the second next, then the third, and to a lesser degree on the fourth and fifth. If the foot is architecturally weak, as appears to be frequently the case in March Foot, then a hypermobile first metatarsal will roll away from this weight, and as a congenitally short metatarsal cannot reach to the ground to carry the strain, then the weight must pass primarily on to the second metatarsal and in decreasing amounts through the third, fourth, and fifth.

Again, the first metatarsal is a much more robust bone than either the second or third, so that structural changes resulting from abnormal strains will be shown much earlier in the latter than the former. Extra stress on the first metatarsal does occur; this is shown by the thickening and increased density of its outer border, i.e., buttressing, this being the side which would tend to bend concavely. This sign is present in all the fourteen radiograms examined (*see Figs.* 81, 87, 88, 89).

The second metatarsal has the following characteristics: (1) It is usually the longest and slenderest; (2) It is the most fixed, especially at its base, where it is firmly embraced by the first and third cuneiforms and also by the bases of the first and third metatarsals; (3) In flat-foot, after the first metatarsal, the brunt of the misplaced weight falls on it.

The next most commonly affected bone, the third metatarsal, also has these characteristics to a rather lesser degree, i.e., it is slender and long, and is more fixed than the first, fourth, or fifth metatarsals.

These points, I think, explain why, when the supporting power of the muscles and ligaments of the calf and foot is exhausted, the second metatarsal will be the first to 'crack' ('crack' probably describes better than 'fracture' what actually occurs), and why the third is next affected.

March Foot is probably an auto-traumatic complication of subacute flat-foot in an architecturally weak foot, rather than a separate clinical entity. The different diagnoses suggested by the many authors who have described it are varying manifestations of the inclusive condition of subacute

flat-foot, e.g., tenosynovitis, spasm of muscles, periostitis, synovitis, arthritis, rheumatism, and finally fracture with callus formation, and do, in turn, at one time or other, play a part in the formation of the picture discussed.

DESCRIPTIVE SUMMARY OF MARCH FOOT.

Etiology.—March Foot is a subacute painful affection of the fore part of the foot, occurring chiefly about the shafts of the metatarsals and the surrounding soft parts. It develops insidiously with slowly increasing pain, which at first arises after prolonged excessive effort, later after ordinary exercise, and ultimately becomes continuous and incapacitates its victim.

It appears to be a condition which is becoming rarer; twenty to forty years ago reports of cases in batches of 15 to 40 were common, but during the last ten years the reports are of much smaller numbers, e.g., Deutschländer[14] 6, Jansen[17] 6, Goldman[19] 1, Straus[20] 1, Dodd 1.

The majority of cases occur in soldiers carrying full packs on active service, although civilians engaged in similar heavy occupations are affected, e.g., a pedlar. With the present-day ample mechanical transport facilities, hard foot-slogging in civilian life is much rarer, whilst periodically in the daily papers appear pictures of the 'mechanized army', so that its incidence in military or civil circles is scarcely likely to be on the increase.

The great military nations, Germany and France, have produced the bulk of the cases and the literature thereon. Doubtless much of their conscript material would not be ideal for the hard soldiering conditions of thirty years ago.

Women with arduous standing and weight-carrying work (e.g., waitresses, shop-assistants, and nurses) also develop the condition.

Clinical Features.—The swelling appears on the dorsum of the foot, centred usually about the shafts of the second and third metatarsals, invading the soft tissues and bone. It scarcely pits on pressure, is slightly reddened, and is tender. A bony swelling of the shaft of one of the metatarsals, usually the second or third, becomes palpable several weeks later. This is callus, which has arisen usually around an oblique or V-shaped fracture of the metatarsal shaft, at the junction of the middle and distal thirds. This fracture occurs quietly without noticeable incident as the condition develops; it is not an exciting factor, and is not always present. The callus may be mistaken for a new growth, suggesting amputation unless March Foot is borne in mind (*see Fig.* 81). On careful elicitation, crepitus may be detected at the site of the swelling.

There are, in addition, signs of a flat-foot with callosities, and spasm of the interossei, denoted by fixity of, and pain on attempts to move sideways, the second or third toes, is usually present.

X-ray Findings.—These are of clinical and historical interest, as March Foot was probably amongst the first conditions to be investigated by radiology, records being available thirty-four years ago. In the fully developed case, X-rays show:—

1. A bony swelling of somewhat fluffy, bulbous outline, due to callus, at the junction of the distal and middle thirds of either, and occasionally even of

both, the shafts of the second or third metatarsals, much less often of the fourth or fifth, and extremely rarely of the first. This swelling is around a partial or complete fracture, usually without displacement. As recovery progresses, it becomes smaller and more sharply defined.

2. In the early stages there is increased density of the shafts of the metatarsals where the interosseous muscles arise, i.e., the second, third, fourth, and inner border of the fifth; the outer border of the first metatarsal shaft is also dense, but the change is most marked in the second or third metatarsal shafts (*see Figs.* 81, 87).

3. According to Jansen, other bulbous swellings may arise about the shafts of the metatarsals, and I have observed slight ones about the shafts of the first phalanges of the second, third, and fourth toes (*see Figs.* 81, 87–89). These are probably due to localized periostitis at the site of attachment of the flexor tendon-sheaths.

4. Of fourteen radiographs of cases illustrated by various authors, all show signs of weak architecture. (This point has already been discussed.)

Pathology. — The bony swelling is firm, pinkish white, and microscopically consists of calcified osteoid tissue with periostitis (Dodd and Straus). It forms at the junction of the middle and distal thirds, this point being the site of entry of the nutrient blood-vessels (Deutschländer[14]). (*See Fig.* 85.)

Diagnosis.—This is suggested by: (1) The patient's occupation; (2) The history of incapacitation due to pain in the fore part of one or both feet; (3) The presence of a swelling partly of the soft tissues and also of the bone about the metatarsal shafts; (4) Occasionally crepitus detected in the metatarsal, which is the seat of the swelling; (5) The X-ray picture; (6) The progressive recovery which follows rest, adequate support, and care of the feet.

In the differential diagnosis arises the question of a sarcoma of the shaft of the metatarsal; the possibility of a syphilitic periostitis, which is excluded by the Wassermann reaction; and a low-grade hæmatogenous osteo-periostitis (Deutschländer) and arthritis in the metatarso-phalangeal joints, but when this is present patients are unable to stand on their toes owing to pain.

TREATMENT.

This consists in :—

1. Rest in bed until the pain and œdema subside, with complete immobilization of the foot or feet by plaster, which is applied to maintain a dorsiflexed and an inverted position with a well moulded arch. If necessary, manipulation of the feet under anæsthetic into this over-corrected position is advisable.

2. With the subsidence of pain, patients get up, and are carefully fitted with stout shoes or boots which adequately support the feet. This foot-wear is adjusted with inside wedges to the heel and sole, metatarsal bars, or even an outside iron with an inside T-strap if necessary.

Patients are carefully instructed in the toilet and care of the feet, a card with the following italicized points printed on it being given to them.

a. Scrub the feet and legs daily in hot water with a soft brush or loofah glove. This ensures a form of homely and effective massage to the feet and muscles of the calf; the actual bending is also beneficial to the abdomen.

b. Wear thick stockings or socks, and change these frequently. These must be large enough, not bunching the toes together.

c. Avoid standing. Standing strains the already weakened calf muscles calling for a sustained muscular effort, whilst walking requires an effort alternating with momentary rests.

d. Walk with the toes pointing directly forwards, never turned outwards. This tends to throw the weight squarely on the forefoot, that is, away from the strained inside arches, and checks lateral stresses.

e. Shoes or boots must be worn from the moment of getting out of bed, until getting into bed at night. This ensures arch support all day.

f. Never walk in soft slippers or in stockinged feet. This avoids unsupported arches.

g. When sitting, the feet should be put up on a chair or couch, if possible. This permits an easy venous return and removes the weight of the legs and thighs from the feet (this is considerable, as is readily realized when carrying an amputated limb, or holding a limb during operation.) Whilst sitting thus, patients may remove their boots, but must put them on before moving.

h. Practise moving the feet and toes up and down about twelve times before or after food daily, also when in bed, on the bus, or on the train. This retones the muscles of the feet and calves, and is definitely helpful, although it appears to be a trivial exercise. Later, walking on tip-toes, and particularly on the heels, should be practised. I regard the latter as the best flat-foot exercise, although it is admittedly difficult.

3. Graduated exercises of the feet and legs are persisted in, to redevelop the lost muscular tone, with the slow resumption of the usual occupation until the muscle power is equal to all ordinary and extraordinary calls likely to be made on it.

4. Obesity, varicose veins, visceroptosis, general muscle flabbiness, and poor bodily carriage are treated, whilst septic foci (teeth and tonsils, etc.) whose toxins diminish muscle tone are searched for, and, if possible, removed.

Finally, in view of the permanent, architectural weakness of these feet, patients must be warned that more consideration of their feet than is usual will always be necessary and that sound, well-fitting footwear must be worn.

I wish to thank my radiological colleague, Dr. R. Parry, for his help in the interpretation of the X-rays he has so kindly lent me to illustrate this article, and also the *Illustrated Sporting and Dramatic News* for the loan of the block of *Fig.* 90.

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SHORT NOTES OF RARE OR OBSCURE CASES

REPEATED PERFORATION OF PEPTIC ULCERS.

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A. W., aged 28 years, was admitted nine years ago with symptoms of duodenal ulcer. Appendicectomy was performed and medical treatment instituted. Two years later he was admitted with perforated duodenal ulcer; the perforation was closed by operation. Nine months later still he was admitted with pyloric obstruction, and a posterior gastrojejunostomy was performed.

On June 4, 1931, he was admitted with perforated jejunal ulcer. The gastrojejunostomy was undone, the stomach and transverse mesocolon were repaired, and the portion of the jejunum containing the ulcer was excised, so that the original anatomy was restored. The pylorus was examined, and, though evidently contracted, it was hoped that it might prove adequate, as the patient had had enough.

He did well for three weeks after this operation, but then began to vomit, at first a little, but gradually increasing until no food was retained. On July 28, the patient being very ill, the abdomen was again opened and an anterior gastrojejunostomy was performed as rapidly as possible.

The patient made an uneventful recovery from the last operation, and remained well until fourteen days before his readmission on Oct. 2, 1932. He was vomiting and had a tender lump in the abdomen, 2 in. above the umbilicus and under the left rectus. This was correctly diagnosed to be a jejunal ulcer and he was put on Hurst's ulcer diet, under which treatment he improved considerably. It was decided to remove a large portion of his stomach in the hope of producing a permanent achlorhydria to prevent the formation of further ulcers.

At operation on Oct. 11 the jejunal ulcer was found perforated into the anterior abdominal wall and there attached. The ulcer was detached and the gastrojejunostomy was undone. This part of the operation was made difficult and tedious by adhesions. The damaged jejunum was resected. The hole in the anterior wall of the stomach was not repaired, but a partial gastrectomy of the Pólya type was proceeded with—the pylorus was found to be completely occluded. The portion of the jejunum used for the anastomosis was just distal to the resected portion and it was brought up anterior to the transverse colon. A gastric ulcer on the lesser curve, hitherto unsuspected, was found in the portion of stomach removed.

The patient made an uninterrupted recovery, and remains quite well and looks extremely fit. Gastric analysis charts (*Figs.* 91, 92) taken before and after operation show that the desired result, i.e., achlorhydria, apparently has been attained.

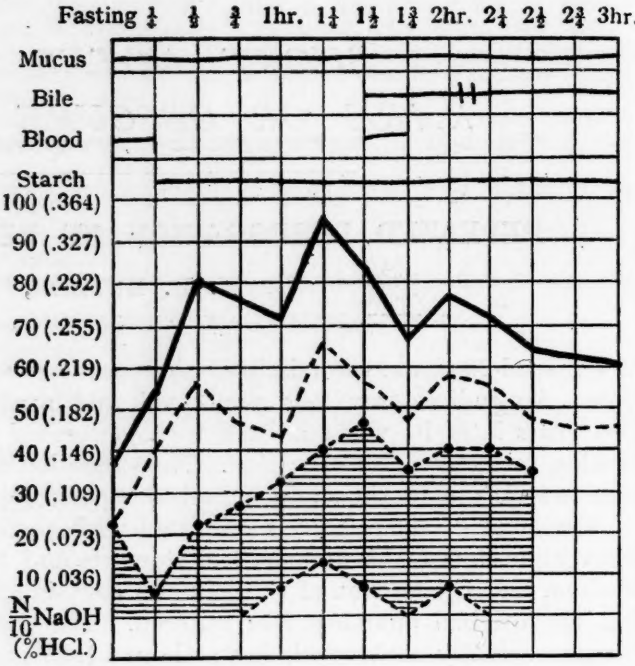

FIG. 91.—Chart taken Oct. 4, 1932, i.e., before operation. Fasting juice, 5 c.c.

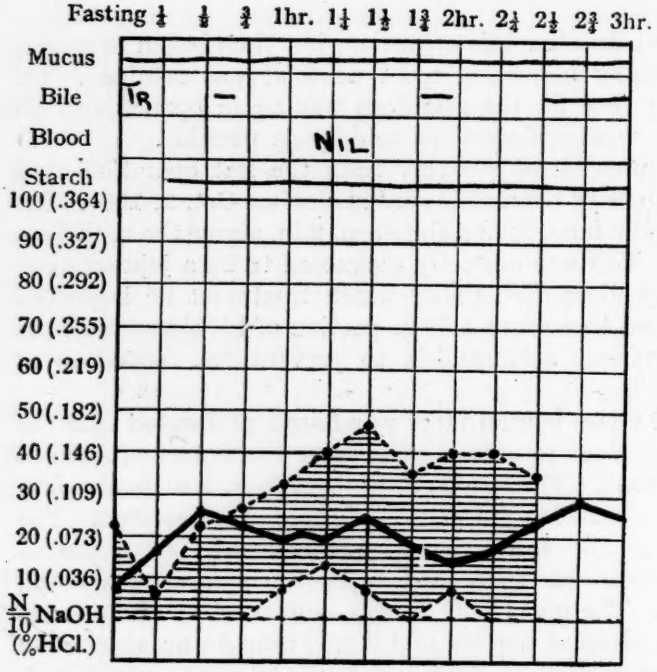

FIG. 92.—Chart taken Dec. 10, 1932, showing complete achlorhydria following gastrectomy. Fasting juice, 12 c.c.

The shaded area represents the limits for free HCl in 80% of normal people, and average rate of emptying (2 – 2½ hours). Broken line represents free HCl. Continuous line represents total acidity.

PEDUNCULATED HYDATID CYST OF LIVER.

By N. ROSS SMITH, Bournemouth.

The following case is recorded because of the rarity of the disease in England and the obscurity of the diagnosis.

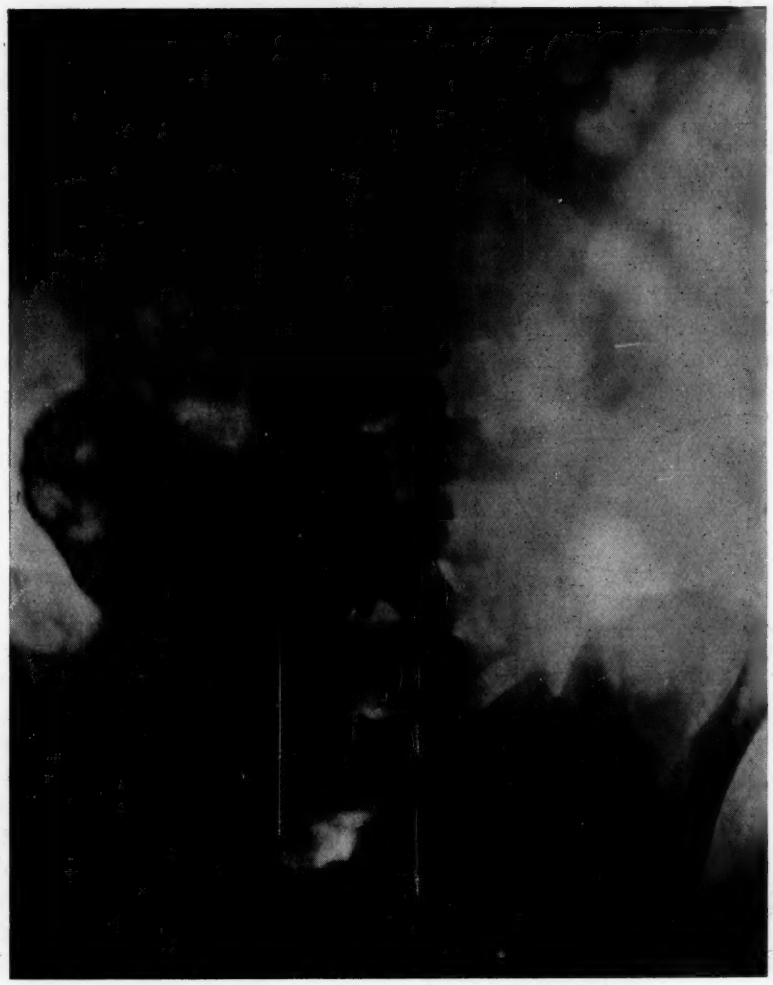

Fig. 93.—Skiagram showing calcified hydatid cyst in abdominal cavity. The pedicle attaching the cyst to the lower border of the liver can be seen. (*Skiagram by Dr. D. D. Malpas.*)

History.—Mrs. H., a lady aged 71 years, gave a history of vague 'indigestion' and attacks of right-sided abdominal pain extending over a period of more than twenty years. The attacks of pain had occurred at intervals of several months up to a year and had lasted from a few hours to a day or two. They had been attributed to 'gall-bladder trouble' and had

subsided without operative treatment. Three weeks before operation she had become jaundiced without pain and had developed intermittent pyrexia of moderate degree. She had lost one stone in weight in the previous six months. All her life had been spent in England, except for a visit to Algiers twenty-four years previously and several visits since then to the French Riviera.

On Examination.—The patient was somewhat wasted and moderately deeply jaundiced. In the abdomen to the right of and below the umbilicus was palpable a slightly movable, firm, kidney-shaped mass. This appeared to be distinct from the liver, which was uniformly enlarged downwards to one inch below the costal margin. The fæces were brown in colour, and tests for bile in the urine were negative. Blood-count: Leucocytes, 22,000; polymorphs, 87·5 per cent; lymphocytes, 5 per cent; mononuclears, 7 per cent; eosinophils, 0·5 per cent. Blood-urea and urea-concentration tests were normal. In a cholecystogram (oral method) no shadow appeared in the region of the gall-bladder, but a shadow of unequal density was seen on the right side, the shape and position of the mass discovered on physical examination (*Fig.* 93). This shadow was thought by the radiologist to be possibly due to accumulation of dye in the cæcum. As hydatid disease was not suspected, no special tests were carried out. A provisional diagnosis was made of carcinoma of the cæcum with metastases in the liver.

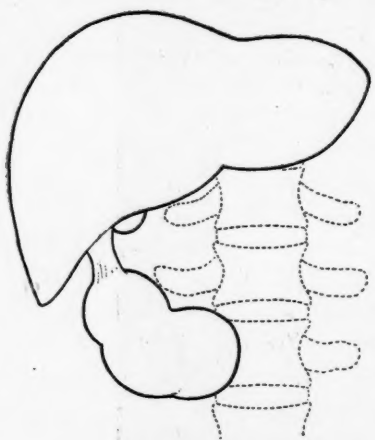

Fig. 94.—Diagram showing size and position of the cyst relative to the liver.

Operation.—At operation the greater omentum was found adherent to the liver and duodenum, obscuring the gall-bladder and ducts, and was wrapped around and toughly adherent to the tumour felt before operation. The omental adhesions were freed and it was then seen that the tumour was hanging from the lower border of the right lobe of the liver by a pedicle of liver tissue, 1½ in. wide, ¼ in. thick, and 1 in. long (*Fig.* 94). This pedicle was ligated and divided and the tumour removed entire. The gall-bladder and ducts were then exposed. The common and hepatic bile-ducts were found greatly dilated, being obstructed by a stone in the ampulla of Vater, which was removed after opening the common duct above the duodenum. The gall-bladder appeared healthy and was not removed. Convalescence was uneventful.

Pathological Report.—The specimen (*Figs.* 95, 96) was sent to the Museum of the Royal College of Surgeons, and Mr. T. W. P. Lawrence kindly reported as follows: "A degenerated and shrunken hydatid cyst. It consists of a main portion, irregularly ovoidal in shape and measuring 4 in. in length and 2½ in. at its widest part and having a well-marked transverse groove at about its middle. Projecting from one side near the lower end is a hemispherical cyst measuring 2 in. in width. At the

FIG. 95.—Drawing of cyst after removal at operation, showing pedicle, areas of calcification, and remains of adherent omentum.

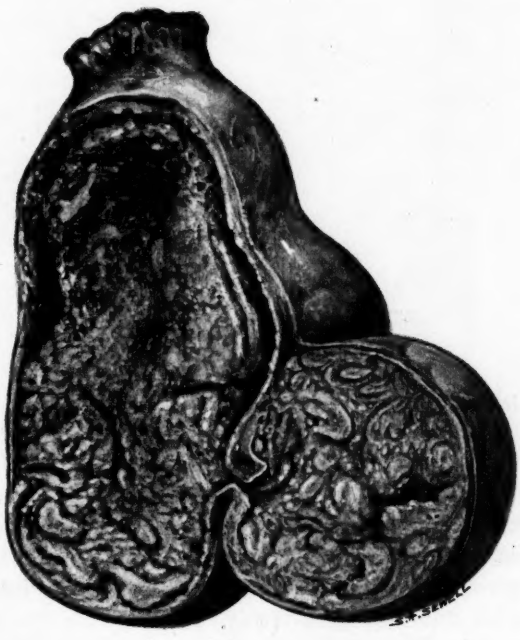

FIG. 96.—Drawing to show the convoluted laminated membrane and granular material in the interior of the degenerated cyst.

other end of the specimen is a raw surface, 1½ in. in diameter, marking the attachment to the liver: in the centre of this several vessels are seen entering the cyst wall. The cyst is completely filled with a gelatinous substance, largely intermixed with mortar-like material; and in the smaller, projecting cyst the contents have partly the form of convoluted, semi-transparent membrane. In the neighbourhood of the pedicle both the contents and the cyst wall are extensively calcified, and in lesser degree calcification affects many other parts of the cyst wall. The cavity of the

FIG. 97.—Microscopic section, showing adventitia, laminated, and germinal layers. (× 20.)

cyst is single, but the main part only communicates with the smaller hemispherical portion by means of an aperture of about ⅛ in. in width. Small portions of omental tissue adhere to the external surface of the cyst. Microscopical examination shows a large amount of granular material, together with sections of portions of the proper wall of a hydatid, exhibiting the characteristic parallel fine striations (*Fig.* 97)."

It seems probable that infection with the parasite in this case was acquired not in England, but in Algiers, where hydatid disease is common.

A CASE OF HYDRONEPHROSIS.

By C. H. FAGGE, London.

Mrs. L., aged 53, has for some years complained of indigestion and sickness. Her attacks usually come on at night, and for the last three months have been more severe; they have no relation to meals or diet. She has fairly constant pain or tired feeling in the back. She has noticed her urine has a high smell, and for some years has got up twice in the night to pass water; for the last four months this has increased, so that she is now getting up about four times each night.

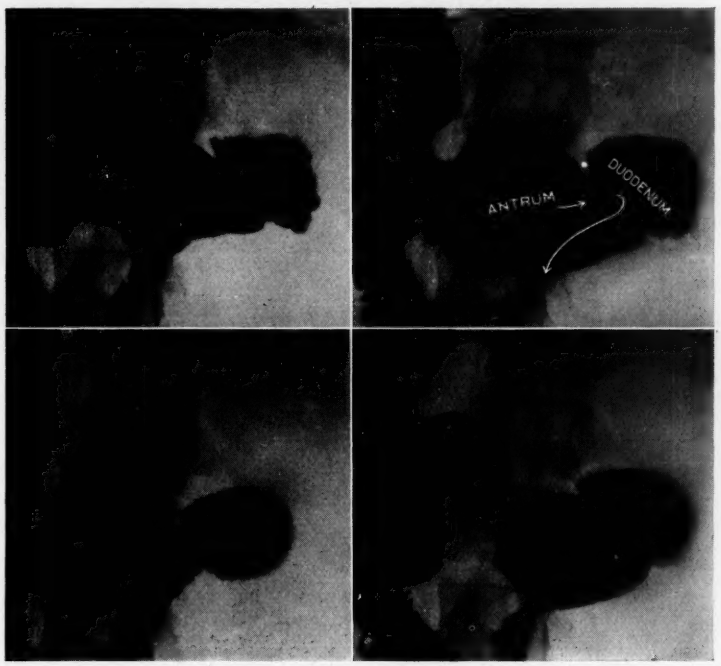

Fig. 98.—Serial view of duodenum taken in the posterior prone position, showing the abnormal position of the second part of the duodenum.

For several years she has found that lying in bed on either side (especially the left) caused heartburn and vomiting; to overcome this she acquired the habit of sleeping flat on her back.

She went to Dr. Rose, of Wimbledon, for the investigation and treatment of her indigestion, and at his suggestion a barium meal was given by Dr. Sparks, who reported as follows:—

"The examination showed a regular contour of the stomach, which was of the normal size with a moderate peristaltic activity and a pronounced convexity of the lesser curvature; the meal passed freely into the first part of the duodenum, which filled well and was globular and regular in outline.

"The second part of the duodenum passed much more medially than usual and showed a well-marked convexity towards the mid-line as if there were some structure displacing it inwards. The serial view of the duodenum (*Fig.* 98) shows this displacement in its upper half. The three-hour radiogram (*Fig.* 99) shows the second part of the duodenum displaced so that the apex of the curve passes just beyond the mid-line of the spine; this view also shows an absence of filled coils of small bowel in the right lumbar region.

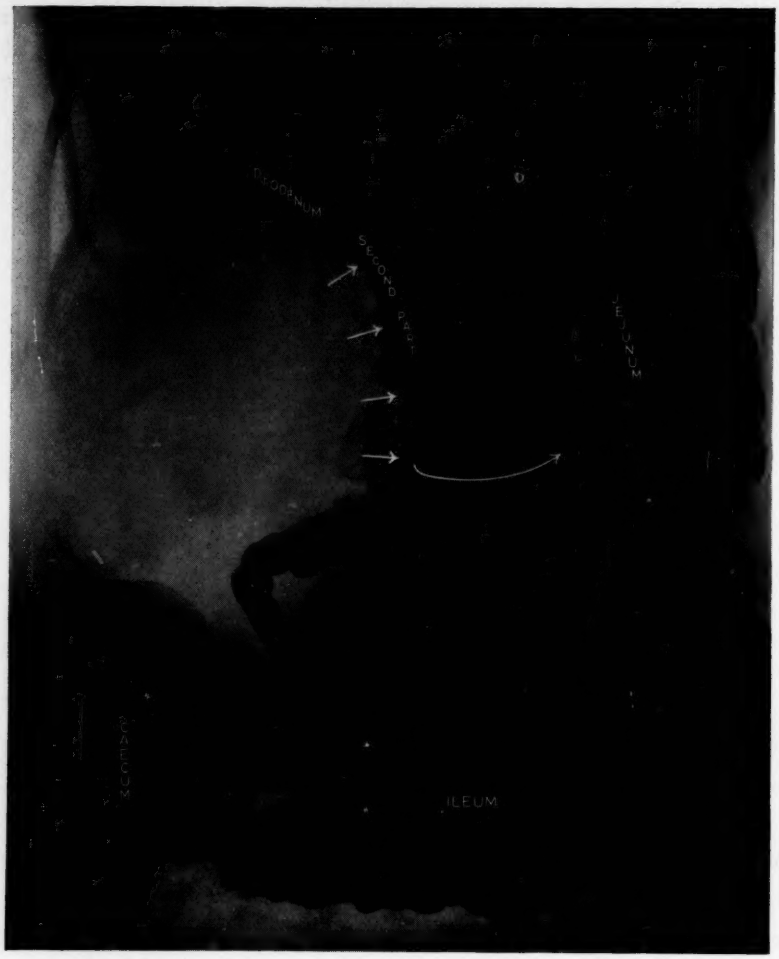

FIG. 99.—Anterior view of the abdomen, taken three hours after the meal with the patient supine, showing the medial displacement of the second part of the duodenum.

"As a result of this examination it was felt that the most probable structure to cause this displacement of the duodenum would be the right kidney. A uroselectan examination was made (*Fig.* 100) and showed the right kidney to be lying low in position and to be enlarged to nearly three times the normal size. Multiple dilated calices became outlined with the dye, and no outline of the pelvis or ureter could be distinguished. The left kidney was seen to lie in the normal position and to be functioning

normally. There was seen to be a scoliosis of the lumbar spine with the convexity towards the left."

Though Dr. Sparks suggested that the right kidney was enlarged to three times its normal size, no definite tumour could be felt on physical examination; but there was a sense of soft resistance in the right loin, which was obviously fuller than the left.

OPERATION.—On Dec. 10, 1932, through a right lumbar incision of the Mayo type, i.e., a vertical along the outer border of the erector spinæ continued forward below almost at a right angle, the outer border of the quadratus lumborum was exposed by dividing the lumbar aponeurosis, and a much enlarged kidney was seen. When it was freed from the perinephric fat, to which it was firmly adherent, it was seen that the greater part of the renal tumour was due to a dilated pelvis. The actual kidney substance was much thinned, being not more than $\frac{1}{4}$ in. thick; the much dilated pelvis ending below in a normal ureter. Anteriorly the junction of the two was crossed by an aberrant vessel of moderate size, apparently a tributary of the renal vein. When this was divided the hydronephrosis did not empty itself. The ureter was ligatured and divided, and the isolated renal vessels were dealt with in the same way. The wound was closed with drainage. The patient made a good recovery: since the operation she can sleep without discomfort on either side and has lost all gastric symptoms.

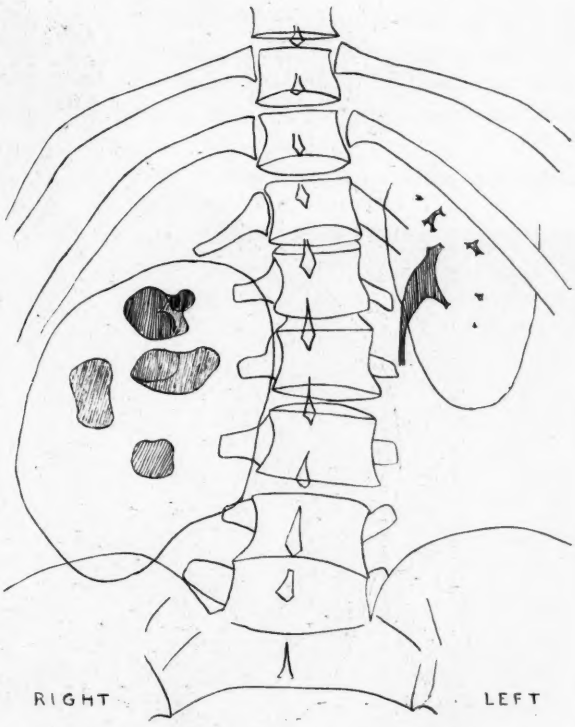

FIG. 100.—Outline tracing of film made twenty minutes after injection of uroselectan.

COMMENT.

The case appears worthy of record because an extreme degree of hydronephrosis had occurred without any urinary symptoms. The location of the disease to the correct organ was, in fact, entirely due to the X-ray report, and we have no knowledge of any previous case in which a renal swelling has so interfered with the passage of substances through the duodenum as to give rise to the appearance such as is seen in the barium X-ray examination. In view of this partial obstruction to the duodenum it is reasonable to suppose that the patient's gastric symptoms were due to the renal tumour, and this

was supported by the fact that since removal of the enlarged kidney she has had no recurrence of these attacks.

After removal from the body it is easy to demonstrate the definite thickening of the ureter at the pelvi-ureteral junction and the valvular type which is usually regarded as due to some congenital error of development, though the question will naturally arise whether this thickening may be caused by fibrosis secondary to ureteral obstruction by the vessels which passed, if not exactly over the point of narrowing, certainly in close proximity to it.

FIG. 101.—Posterior aspect of kidney. (× ½.)

We have never been able to convince ourselves that a soft vessel like a vein can obstruct the thick-walled ureter; it appears to us that the main factor in hydronephrosis attributed to abnormal vessels is associated abnormality of the kidney. There is no evidence that this patient's kidney ever was unduly mobile, and, on the contrary, at the time of operation it was found to be unusually fixed from adherence of its capsule to the perinephric fat.

The drawing of the specimen (*Fig.* 101) shows clearly that the displacement of the duodenum was due to a 'pelvic' hydronephrosis: probably this is less common than the renal type, and, if so, an explanation is afforded of the suggestion that such a radiological appearance has not been previously recorded.

A DIVERTICULUM OF THE FIRST PART OF THE DUODENUM.

By G. E. GASK,

SURGICAL UNIT, ST. BARTHOLOMEW'S HOSPITAL.

Duodenal diverticula have become well known since the advent of X rays and the use of the opaque meal as a routine method of examination of gastric cases. The large majority of these pouches are found in the second part of the duodenum, and though anatomists, noticeably J. C. Grant,[1] have recorded pouches arising from the first part, the details of a case which was operated on seem to merit a record.

The patient was a man, aged 37, with a history suggesting duodenal ulcer. One day he had a sudden severe attack of abdominal pain, suggesting a perforation, which brought him to hospital.

Fig. 102.—Radiogram showing a duodenal ulcer and a diverticulum.

The X-ray diagnosis was a duodenal ulcer and a diverticulum, which filled and emptied easily from the first part of the duodenum (*Fig.* 102). At operation this condition was confirmed. There was an ulcer of the duodenum which had perforated and been sealed off by peritoneal adhesions, and there was a pouch arising from the lower border of the duodenum just distal to the pylorus and proximal to the ulcer. The pouch was about 1½ in. long by 1 in. in diameter, and the opening into the duodenum was large enough to admit the tip of the finger. It was soft and thick, resembling the stomach in texture.

It was considered that the pouch was of congenital origin, there being no evidence to suggest that it had formed as the result of pressure.

The pouch was excised and a gastrojejunostomy performed. There is nothing to note concerning the after-history of the patient. Histological examination showed normal duodenal structure.

REFERENCE.

[1] Grant, J. C., *Jour. of Anat.*, 1923, lvii, 357.

A CASE OF CARCINOMA OF THE RIGHT BREAST FOLLOWED BY SARCOMA OF THE LEFT BREAST AFTER AN INTERVAL OF EIGHTEEN YEARS.

By CECIL P. G. WAKELEY,
SURGEON TO KING'S COLLEGE HOSPITAL.

THE following case is of interest because the patient suffered from a scirrhous carcinoma of the right breast which was removed in 1914, and was not followed by a recurrence or secondary deposits. After an interval of eighteen years, at the age of 89, a hard tumour was discovered in the left breast and when the breast was amputated it was found to be a chondrosarcoma.

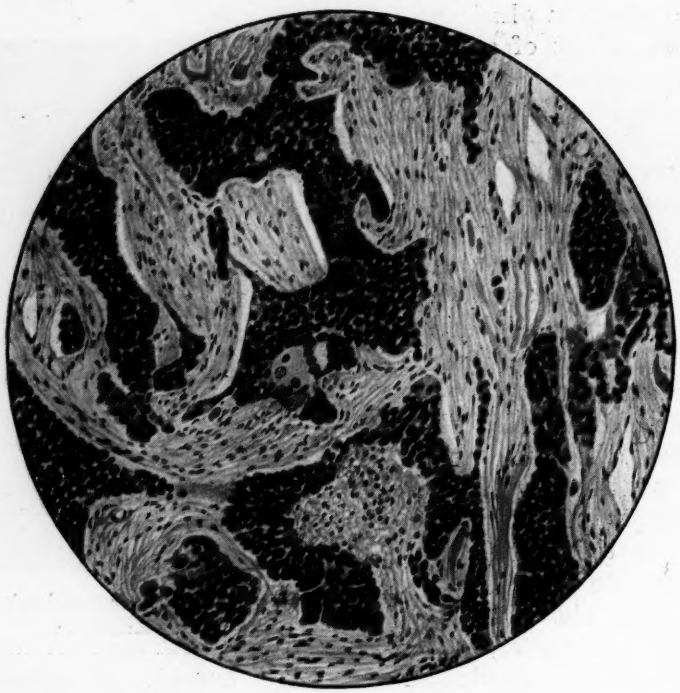

FIG. 103.—Microscopic section of right breast, showing typical spheroidal-celled carcinoma. (× 130.)

The clinical history is as follows :—

Mrs. A. M. B., age 71, was operated upon in 1914 for a tumour in the right breast. The patient had noticed the lump for just over a year. The tumour was hard, about the size of a hen's egg, and situated in the upper and outer quadrant of the breast; it was attached to the skin, but not to the pectoral fascia. There were a few hard glands in the axilla. Although the patient was 71 years of age her general condition was good, and a radical removal of the breast was advised. The operation was

performed as completely as possible; both pectoral muscles were removed with the breast and all the fat and glands in the axilla. The patient made a rapid recovery and was able to return to her home within three weeks of the operation.

Microscopical examination of the tumour of the breast proved it to be a spheroidal-celled carcinoma of the scirrhous type. The glands and fat removed from the axilla did not reveal any carcinomatous invasion when examined microscopically.

My colleague, Dr. Creed, reported as follows on the microscopical section of the tumour: "The section shows a spheroidal-celled carcinoma (*Fig.* 103). The tumour cells are arranged in masses of moderate size with no definite lumen formation. Small strands, a single cell thick, can be seen invading the stroma. Stroma and tumour masses are present in approximately equal proportions. The stroma is composed of fibrous tissue of moderate density, and shows no cellular infiltration with lymphocytes or plasma cells."

FIG. 104.—Microscopic section of left breast, showing chondrosarcoma. (× 130.)

The patient remained very well until June, 1932, when a hard lump was noticed in the left breast. She was 89 years of age and somewhat senile and infirm, and could not say how long she had known the tumour to be present. The tumour was about the size of an orange, it was hard and irregular to the touch, but was not attached to the skin or to the underlying structures. There were no enlarged glands in the axilla.

Local removal of the breast was decided upon because it was thought that the tumour might eventually fungate through the skin. A radical

amputation was considered too severe an operation for a patient of her age and in a feeble condition.

On June 22, 1932, a local amputation of the breast was performed under gas and oxygen anæsthesia. The patient stood the operation well and convalescence was uninterrupted. The wound healed soundly. The tumour was hard and occupied practically the whole of the small senile breast.

Dr. Creed examined the tumour and reported as follows: "The sections show a chondrosarcoma (*Fig.* 104). There are some areas which show fairly typically the appearance of a spindle-celled sarcoma with some deposition of collagen fibrils and with active mitosis. Most of the tumour, however, is chondromatous in structure with cells resembling cartilage cells embedded in a matrix which varies in appearance. Some parts of the matrix are hyaline and eosinophil, and others are fibrillary and tend to be basophil. Some of the tumour is necrotic. The spindle-celled areas are principally towards the periphery of the tumour but merge without any sharp line of demarcation with the chondromatous areas."

The patient was examined in March, 1933, and is in good health with no signs of recurrence.

CASE OF HERNIA INTO THE FOSSA INTERSIGMOIDEA.

By RONALD REID, Colchester.

Cases of retroperitoneal hernia in the fossa intersigmoidea are rare; two have been reported in detail. The first is the case described by Eve in the year 1885, the second was recorded by McAdam Eccles in 1895.

The intersigmoid fossa was first mentioned in 1742 by Hensing, and then in 1769 by Haen, by Roser in 1843, Treitz in 1857, and also by Waldeyer in 1868. It is present in the majority of subjects—according to Treves in 52 per cent. Moynihan found the fossa in 70 per cent, Waldeyer in 84 per cent, of cases examined. The opening of this fossa is found by turning the pelvic mesocolon over to the right, and it is then seen as an oval orifice at the root of the mesentery. The long axis of the oval is transverse and measures about 1½ in. The fossa in the adult varies from a small depression up to the size of a hen's egg. One case of a much larger fossa has been described; here the fundus reached to the aortic bifurcation. The opening lies over the left psoas muscle, and is bounded in front by a sharp peritoneal fold; below and behind the boundary is the smooth parietal peritoneum sweeping up into the fossa. The long axis of the fossa is directed from below upwards and to the right, the fundus usually reaches the bifurcation of the common iliac vessels in a well-marked specimen, and in the posterior wall of the pouch is the ureter.

The following case report is of interest by reason of the rarity of this form of hernia. It appears that this hernia is not discovered apart from acute intestinal obstruction.

The patient, an old woman aged 69 years, was admitted to hospital in February, 1931. Ten days before admission she had noticed mild colicky

pains in the lower part of the abdomen. After two days the pains became worse and vomiting occurred; the pains continued and there was an action of the bowels on the following day. There was an action again on the next day, but for the five days previous to admission there was absolute constipation. Two days before admission fæcal vomiting started and the pains became intense and almost continuous; they were still colicky in nature, and greatest to the left of the lower abdomen. An enema was given, but it failed to give relief.

The past history contained nothing relevant to the present condition.

On Admission.—The general condition of the patient was poor in the extreme. The expression did not indicate severe toxæmia, but the pulse was feeble and thready, the rate being 108; the temperature was subnormal. The abdomen was grossly distended, chiefly in the hypogastrium, and was tympanitic on percussion. No intestinal movements were seen or heard. Tenderness was general, but as the left iliac fossa was approached the pain on deep palpation was very severe. On rectal examination general abdominal pain was produced, and nothing abnormal could be felt. The urine was normal.

A diagnosis of acute intestinal obstruction was made. The descending or pelvic colon was thought to be the site of the obstruction and its nature carcinomatous.

Operation.—The patient was given $\frac{1}{4}$ gr. of morphia and taken to the theatre. It was found that the general condition was deteriorating very rapidly, and it was therefore decided that the only chance of saving the patient was by relieving the obstruction as quickly as possible through a blind cæcostomy. Accordingly a local anæsthetic was given and the abdomen opened by a grid incision over the cæcum. At once a distended coil of small intestine pushed through the incision, and the collapsed cæcum was discovered. The small intestine was so dilated and engorged that it was only after increasing the original incision that the site of obstruction was found in the left iliac fossa. The exact nature of the obstruction could not be made out, the bowel could not be freed, and the patient was almost *in extremis*. No further time was lost, the coil of distended bowel next to the obstruction was clamped and very rapidly anastomosed to the coil of collapsed intestine found below the obstruction; the anastomosis was stitched to the parietal wound and a soft rubber catheter was inserted into the upper coil, just above the site of anastomosis. The abdominal wound was closed with free drainage: 40 c.c. of anti-gas (*B. welchii*) serum were given intramuscularly.

The state of the patient began to improve after four hours, vomiting ceased, and the discomfort diminished. Distension was less, although there was only moderate drainage from the enterostomy. Glucose rectal saline (6 per cent) was ordered four-hourly; the patient could retain only 4 oz., and after twenty-four hours could retain practically none. It was decided that fluid must be put into the circulation by the intravenous route. The serum was repeated and 500 c.c. of gum saline were run into the right median basilic vein, fifty minutes being occupied with this operation. At the end of the injection the patient complained of pain in the left hand, then in the

arm, and finally in the chest behind the sternum. There was shortness of breath, and gradually the patient became unconscious, sank slowly, and died about thirty-four hours after the time of the laparotomy.

POST-MORTEM.—The abdomen contained a few coils of distended and thickened small intestine and the remainder of the small and large intestine, collapsed and to all appearances normal. There was an obstruction of the jejunum about four feet from the duodenojejunal flexure where the intestine entered a pouch on the lower aspect of the pelvic mesocolon. The jejunum entering the pouch was thickened, and appeared to be hypertrophied, as though the obstruction was of long standing. With little difficulty the loop of jejunum was withdrawn from the pouch; there were some adhesions, and considerable œdema of the loop and of the pelvic mesocolon adjacent to the hernial opening. The loop withdrawn was about 5 in. in length, dark purple in colour, and showed a patch of gangrene at the site of constriction of the entering limb.

The opening of the fossa into which the bowel had entered was on the lower and left-hand aspect of the pelvic mesocolon, at the parietal border. The shape was oval, measuring about 1½ in. by 1 in., the long axis running parallel with the colon. The anterior lip of the opening was a crescentic band of peritoneum, the posterior lip was not well marked, and was where the parietal peritoneum over the left psoas muscle swept up into the fossa. The sac was about 3 in. deep, and the fundus of it was directed upwards towards the sacrum, and backwards over the brim of the pelvis. The lower or left-hand wall of the sac lay over the left psoas muscle and the left ureter. The upper wall was the root of the pelvic mesocolon and iliac mesocolon. The lining was peritoneum and only slightly thickened. The remainder of the colon and cæcum and mesenteries were normal. Other abdominal viscera were normal. The coronary vessels and aorta were atheromatous.

REVIEWS AND NOTICES OF BOOKS.

The Principles and Practice of Rectal Surgery. By WILLIAM B. GABRIEL, M.S. Lond., F.R.C.S., Surgeon to St. Mark's Hospital and the Royal Northern Hospital. Royal 8vo. Pp. 248 + viii, with 118 illustrations, including 8 coloured plates. 1932. London: H. K. Lewis & Co. Ltd. 20s. net.

THE author says in the preface that the object he had in view when undertaking the task of writing this book was the production of a practical guide to the diagnosis and treatment of diseases of the rectum. We have no doubt that those who read the book will agree that he has succeeded well.

The opening chapter deals with diagnosis, the various methods of examination being minutely described. Excellent advice is given by emphasizing the necessity of re-examination in difficult or obscure cases, and by the warning that a double lesion may exist. The preparation of cases for operation and routine methods of after-treatment are carefully described, much valuable information being given therein. When discussing the various methods of inducing anæsthesia the author shows a decided preference for low spinal anæsthesia by intrathecal stovaine.

The subject of hæmorrhoids is discussed in detail. The method of treatment by injection is fully described and helpful instruction is given as to the efficient manner of carrying it out. Operative treatment is confined to the description of the method of catgut transfixion, which the author prefers to all others. The illustrations of the various steps of the operation might, we think, have been made clearer with advantage.

For the treatment of prolapse of the rectum submucous injections of phenol in oil and perirectal injections of quinine are considered to give the best results.

A novel type of operation is described for the cure of a chronic fissure. A triangular incision is made with a scalpel, starting from the anal margin on each side of the fissure. The lateral incisions vary in length from 2 to 2¼ in. and are joined by a transverse incision at their posterior extremity. The length of the transverse incision is not mentioned, but according to the illustration it appears to be about 2 in. long. The skin enclosed by these incisions is removed, with the result that a considerable wound area is left to heal by granulation. It is claimed that the removal of so large an area of healthy skin is necessary to establish drainage for the fissure. The resulting wound takes about five weeks to heal and it is necessary for the patient to desist from running, riding, or playing strenuous games for several months, thus entailing a lengthy convalescence. We fail to see the necessity for sacrificing so large an area of healthy skin, since, in our experience, the simple operation generally performed gives excellent and permanent results, complete cicatrization taking place in three weeks.

For the treatment of ischiorectal abscesses extensive sacrifice of healthy skin is also advocated, subsequent skin-grafting of the granulating surface being necessary to expedite healing.

Seven varieties of anorectal fistulæ are described. Such a classification is purely arbitrary and is not based upon the anatomical sites of the preceding abscess. It is estimated that 15 per cent of anorectal fistulæ are tuberculous.

The etiology, pathology, and the various methods of treatment of pruritus ani are fully discussed. The author has achieved excellent results by the injection of A.B.A. and percaine in oil, his percentage of cures being estimated at over 60 per cent.

The chapter dealing with benign growths is very instructive, the pathological appearances, microscopical as well as macroscopical, being minutely described.

The concluding chapter is devoted to cancer of the rectum, of which a very excellent account is given, including histological classification, methods of routine examination, the value of proctoscopy and sigmoidoscopy, abdominal and general examination, the use of the barium enema, and the interpretation of results. When discussing the spread of cancer of the rectum it is contended that extrarectal spread by means of the lymphatics only takes place after the deep infiltration has passed beyond the rectal wall. It is pointed out that Duke's classification of 215 cancers of the rectum removed by surgical operation shows that in 53 per cent dissemination by means of the lymphatics had not occurred. The natural conclusion, therefore, is that in the 215 operable cases of cancer of the rectum a restricted resection with end-to-end anastomosis would have been sufficient to prevent recurrence in nearly 50 per cent. This seems to us to be an optimistic estimate. It must be extremely difficult to be sure, even after a most thorough examination of a given specimen, that not even a single cancer cell—quite sufficient to give rise to a distant metastasis in the extrarectal lymphatic areas—had escaped detection.

For the surgical treatment of cancer of the rectum the author recommends perineal excision for growths in the ampulla, and perineo-abdominal excision for those at or above the recto-sigmoidal junction. Excellent descriptions of the technique of both operations are given, together with statistical tables setting out the mortality and the survival rates for three and five years.

Little encouragement is offered for treating cancer of the rectum with radium. We agree with the author when he says " a patient's troubles are only just beginning when a radium implantation is given."

We have nothing but praise for this book. It is well written, excellently illustrated, and replete with sound practical instruction.

Chirurgie du Rectum. By HENRI HARTMANN, Professeur de Clinique chirurgicale, Chirurgien de l'Hôtel-Dieu. Imperial 8vo. Pp. 398, with 161 illustrations. 1931. Paris: Masson et Cie. Fr. 75.

THIS is the best book upon the surgical treatment of diseases of the rectum in the French language with which we are acquainted. It embodies the author's conclusions in regard to the best methods of treating rectal disease, based upon an experience of over thirty years, and is therefore extremely valuable.

The opening chapter is devoted to methods of examination; the various instruments devised for purposes of diagnosis are accurately described and hints given in regard to their proper use. Perirectal suppuration is exhaustively considered in the succeeding chapter, prominence being given to the diffuse forms—namely, septic perirectal cellulitis and diffuse gangrenous phlegmon. It is pointed out, however, that these varieties are not so frequently met with after perineal operations nowadays owing to antiseptic and aseptic methods of procedure. Localized suppuration is considered to be due to septic lymphangitis and phlebitis originating in an abrasion of the mucosa of the anal canal and rectum. Five varieties of circumscribed abscess are described—namely, the submuco-cutaneous, the submucous, the ischiorectal, the pelvirectal, and the retrorectal.

The subject of ano-rectal fistula receives elaborate consideration. The opinion is expressed that, whereas a considerable number of fistulæ are preceded by an abscess of septic origin, quite 50 per cent are tuberculous. The usual classification of fistulæ into complete, blind external, and blind internal varieties is adhered to, but it is insisted upon that the relationship of the main track to the musculature of the anal outlet is of great importance. Three types of ano-rectal fistulæ are described—namely, the subcutaneous, the submucous, and the ischiorectal. In the author's experience spontaneous cure seldom occurs, and therefore the treatment of the various types of ano-rectal fistulæ is by surgical operation. The details of operative procedure are carefully described for each type. An operation which appears to be greatly favoured by the author, the various stages of which are excellently illustrated, is excision of the main track. After completely dissecting out the track as far as the internal opening, the mucosa surrounding the opening is

excised together with the mucosa between the opening and the muco-cutaneous margin. Finally, the rectal mucosa is brought down to the skin margin and sutured there. It is claimed that by excising the internal opening, fæcal contamination of the wound is obviated and the wound heals rapidly. It is obvious, however, that the method is only applicable to those fistulæ in which there are no offshoots from the main track.

For the operative treatment of internal hæmorrhoids the author advocates preliminary forcible dilatation of the sphincters. A combined ligature and cautery operation is the method of choice. Whitehead's operation is also recommended.

Prolapse of the rectum receives considerable attention. Only two varieties are recognized—namely, prolapse of the mucous coat only, and total prolapse in which all of the coats of the rectum are involved. For the treatment of total prolapse several surgical procedures are described, including colopexy, posterior rectopexy, removal of an extensive area of mucosa by means of the thermocautery, and amputation of the prolapse by the method advocated by Mikulicz.

The chapter dealing with stricture of the rectum is one of the best in the book. We know of no better account of the etiology of the disease. According to the author's experience, stricture of the rectum occurs almost as frequently in men as in women. In his opinion perineal excision yields the best results, the operative mortality being as low as 5 per cent.

The pathology, symptomatology, and the spread of cancer of the rectum are very lucidly described. Especial stress is laid upon the frequency with which cancer spreads in an upward direction in the pelvic mesocolon along the line of the superior hæmorrhoidal vessels. Kraske's operation is minutely described, and there are excellent illustrations showing the varying amounts of bone removed in the modifications introduced by his followers, notably Hocheneg, Bardenheueur, Rose, and Heinecke. It is stated that the operative mortality of these operations varies from 11 to 20 per cent. Excision by the perineal and the vaginal routes are also well described and illustrated. The operative mortality of perineal excision is estimated at about 14 per cent. The technique of the abdomino-perineal operation is described in detail and is well illustrated. The only point to which we take exception is that the greater part of the peritoneum lining the floor of the pelvis is left behind. In our view the pelvic peritoneum is highly dangerous tissue and should be removed widely. The operative mortality of the abdomino-perineal operation is estimated at 26 per cent, and consequently the author advocates Coffey's two-stage method as a means of reducing the mortality rate.

The concluding chapters are concerned with benign tumours and the operation of colostomy, but these do not call for any special comment.

An Introduction to 'Avertin' Rectal Anæsthesia. By J. Kempson Maddox, M.D., Ch.M. (Sydney), M.R.C.P. (Lond.), Tutor in Medicine, University of Sydney. With a Foreword by Harold R. Dew, M.B., F.R.C.S., F.R.A.C.S., Professor of Surgery, University of Sydney. Large 8vo. Pp. 124. Illustrated. 1931. Sydney: Angus & Robertson. 9s. net.

As the author states in his preface, this little book is based on only two years' experience of the use of avertin, and is intended as an interim guide for the assistance of those general practitioners who wish to employ it. In spite, however, of the author's modest description of its aim, it consists of a very able review of the literature on the subject (together with an Anglo-American bibliography) as well as the results of his own experience. No one, whether he be anæsthetist or general practitioner, who has not used avertin could find a more helpful guide than this manual.

The book begins with an historical survey of the use of rectal anæsthesia in general, and the pharmacology of, and general considerations connected with the use of, avertin in particular, the possible complications resulting from its use and their treatment, and finishes with an account of the author's technique, and a general review of the position occupied by the drug in anæsthesia at the time of writing.

The book is easy to read in spite of some ambiguity in parts. The author favours the use of avertin in the majority of cases, especially in the surgery of children and in all those who have repeatedly to undergo painful dressings. Repeated exhibition of the drug in the same patient, as in cases of tetanus, does no harm. He discusses fully its contra-indications and shows how few these are in actual practice.

However, we do not agree with all the statements on the subject, e.g., that it is a perfect relaxing agent in abdominal surgery. If it is so in Australia, the patients there must be rather different from those found in London, or perhaps we should blame the anæsthetics to which the author has been accustomed. His statement that it is the best preliminary medication is open to question, the great drawback to its use in this connection being the technique of its preparation, administration, and posology. In our opinion the newer barbiturates given by the mouth, with or without derivatives of opium and hyoscine, do all that can be done by avertin with only a fraction of the trouble and care necessary in connection with the latter's use. This must not be taken as meaning that there is no place for this drug in anæsthesia, but merely that it is not the only drug that can produce these desirable effects.

In the author's opinion the preliminary cleansing enema can be dispensed with, and in urgent surgery "no harm has resulted from its omission". He also administers the drug only twenty minutes before the operation, though in our experience its full effect is not evident for at least forty-five minutes. He makes an extraordinary statement in the last few pages when he says that either "intravenous avertin" or nitrous oxide is the most suitable anæsthetic agent "for very short operations (e.g., dental extractions)". It is the only reference in the book made to intravenous avertin and one wonders whether he intended to say something else. He also refers to the "initial pain" associated with spinal analgesia, which apparently is peculiar to Australia, as we have no experience of it.

In his treatment of respiratory failure he recommends lobeline "1½ grains, 0·1 gm." as "an injection", without stating what kind of an injection—whether hypodermic, intravenous, or rectal. In no case have we ever given more than 10 mgrm. at a time, and would hesitate to do so.

On page 80 it is stated that "children up to ten years of age . . . should be given atropin sulphate dissolved in chloroform water by the mouth in a dose of approximately 0·32 mg. ($\frac{1}{200}$ gr.) *for each year of age.*" This statement is obviously made in error, as it would mean, for example, that a child of 10 should be given $\frac{1}{20}$ gr.

Also on page 90 the author states rather ambiguously that "gr. $\frac{1}{6}$ (0·012 gm.) of morphine must be given with 0·11 gm. of avertin per kg. of body weight". His comparative doses are not always correct. On page 90 he writes "gr. $\frac{1}{6}$ (0·012 gm.)" and in another place "gr. $\frac{1}{6}$ (0·010 gm.)", which is the usually accepted equivalent and which he gives in his table at the end of the book.

However, apart from ambiguity here and there and some inconstancy in the relationship between imperial and metric measures and some mistakes in posology, the book is well worth reading. In our opinion avertin is more of a narcotic than either an analgesic or anæsthetic, and this apparently is the opinion of the manufacturers who describe it as a '*basal* anæsthetic'.

De l'Exclusion haute de l'Estomac. By BERNARD-OLIVIER GUIHENEUC. Royal 8vo. Pp. 76. 1932. Paris: Imprimerie Lahure.

THIS small pamphlet describes twelve cases in which high exclusion of the stomach was performed for duodenal ulcer (6), pyloric ulcer (2), lesser-curvature ulcer (2), and bleeding ulcers (2). The operation consists of division of the stomach beginning as high as possible on the lesser curvature and reaching the greater curvature at a point slightly to the left of this. On the distal side a simple and complete closure is effected, on the proximal side an anastomosis with the jejunum of 6 to 8 cm. of the stomach at its dependent and divided edge, the rest of the stomach above being closed. At this stage the ulcer is left alone, but at a second operation the middle

and pyloric gastric segments may be removed—in fact, a two-stage partial gastrectomy may be performed.

The point of interest is that the second stage may be dispensed with altogether and the patient suffer in no way, except by the retention of an ulcer scar which may be the seat of malignant disease later. The indications for the operation are chiefly: (1) Hæmorrhage from duodenal and gastric ulcer; (2) Adhesions round an ulcer making immediate resection difficult; (3) The serious condition of the patient. The twelve cases are adequately described. One pyloric ulcer and one lesser-curvature ulcer died from hæmorrhage.

Trattato di Patologia chirurgica generale e speciale. By Prof. OTTORINO UFFREDUZZI (Turin). Large 8vo. Vol. I. Pp. 724 + vi, with 345 illustrations and 8 coloured plates. 1933. Turin: Unione Tipografico-editrice Torinese.

THIS handsome book, with excellent type and binding, is a credit to the publishers and to the University of Turin. The title, "Surgical Pathology, General and Special", does not convey to English readers quite what it is. The author is known for his practical bent and common sense. He has furnished his students with a text-book of applied pathology that reflects his teaching in wards and theatre, and includes, therefore, more in the realm of treatment than would be found in an English book of similar title.

No fewer than 167 pages are devoted to fractures, not only in their general aspect, but also including details of treatment and prognosis, whilst only 90 pages are spent upon non-traumatic affections of the bones. Similarly 64 pages are given to injuries of joints, and 108 to all inflammatory affections, including tuberculosis.

The present volume also has sections upon the muscles, tendons, bursæ, heart, and vessels. For the general reader the first 150 pages are of greatest interest. There is an historical introduction of 25 pages, which gives Professor Uffreduzzi legimate opportunity for dwelling upon the greatness of Italy's contribution to the science and art of medicine, but in which he nevertheless presents a fair perspective setting for modern studies. The first section of the text proper deals with repair, the second with inflammation in general, with infection, and with specific infections. As throughout the book, the outlook is sensible and judged from the practical rather than the theoretical standpoint. For example, in dealing with the use of vaccines in acute infections, it is pointed out that stimulation of the organism cannot be lacking when myriads of germs are circulating in the blood, undergoing destruction and pouring endotoxins into the circulation. The subject of tumours in general receives only 16 pages, but the account is very interesting. Incidentally, the views expressed upon irradiation as a means of treatment reflect the Turin School under Bertolotti rather more exclusively than is characteristic of the rest of the book, which constantly reveals the author's acquaintance with the work and literature of Germany, France, America, and England.

A fourth section is headed "Relations between the Theory of the Constitution and Surgical Pathology", and gives opportunity for general talk about heredity, internal secretion, deformities, atavism, anomalies of biochemical activity, and so on. "The individuality factor not only has great value in biology and psychology, but actually dominates the field of pathology. . . ." "For the surgeon, the personality of the supporting tissues, and particularly the connective tissues, is especially important, since it is the essential factor in all reparative processes. . . ." Scores of such sentences could be quoted which are so written as to catch the attention and illuminate a point.

Students who can read this book and remember it will certainly have a grasp of the principles of surgery. It is fully illustrated, and the text figures are adequate, but readers of this JOURNAL will note with some surprise, after reading the list of acknowledgements of Italian sources in the preface, that the best of the plates are extremely familiar to them, and bear the well-known names of Sewell or of Maxwell, where they are accustomed to see them. They may even know the specimens.

Arthritis deformans und chronische Gelenkkrankheiten. By Prof. Dr. HANS BURCKHARDT (Essen). Royal 8vo. Pp. 464 + xii, with 70 illustrations. 1932. Stuttgart: Ferdinand Enke. Paper covers, RM. 53; bound, RM. 55.50.

THIS monograph, one of the series of 'Modern German Surgery,' contains a thorough and systematic account of chronic specific and non-specific joint diseases. The clinical picture, pathology, treatment, and prognosis of all are well described. The pessimistic view that chronic arthritis follows operations for the removal of the semilunar cartilages with considerable frequency does not agree with the experience of British surgeons; it is interesting to observe that the writer condemns the prevalent Continental practice of dividing the internal lateral ligament in cartilage operations.

For a book of this size the illustrations are few, but most of them have been chosen well. Extensive reference is made to Continental, English, and American literature on the subject.

Die unspezifischen chronischen Erkrankungen der Wirbelsäule. By Prof. Dr. HANS BURCKHARDT (Essen). Royal 8vo. Pp. 77 + vi, with 22 illustrations. 1932. Stuttgart: Ferdinand Enke. RM. 7.50.

THIS monograph is a continuation of this author's work on chronic joint diseases. It contains an exhaustive account of the chronic non-specific diseases of the spine, some of which are illustrated. Extensive reference is made to Continental literature, chiefly to the work of Schmorl and Calvé.

The Science and Practice of Surgery. By W. H. C. ROMANIS, M.A., M.B., M.Ch. (Cantab.), F.R.C.S. (Eng.), F.R.S. (Edin.), Surgeon and Lecturer on Surgery, St. Thomas's Hospital, etc.; and PHILIP H. MITCHINER, M.D., M.S. (Lond.), F.R.C.S. (Eng.), Hon. Surgeon to H.M. the King, etc. Fourth edition. Royal 8vo. In two volumes. Vol. I, General Surgery. Pp. 865 + x, with 373 illustrations. Vol. II, Regional Surgery. Pp. 1045 + x, with 326 illustrations. 1932. London: J. & A. Churchill. 14s. net per vol.

No better testimony could be given to the value of this work on surgery than the fact that it has within very few years run through four editions. In considering the fourth edition one is naturally particularly interested in those chapters which have been rewritten, or to which new material has been added. That on blood transfusion is sound and practical, but for the education of students it would be well to include the signs and symptoms of imperfect grouping. In the preface it is claimed that the chapter on fractures has been brought into line with modern work, yet space is devoted to Sinclair's skate, and several figures of the ice-tong calipers appear; both of these have surely been superseded by Steinmann's pin, and this has given way to Kirschner's wire. Other revised chapters on the sympathetic nervous system and the spleen are most disappointing; they appear to be written on a classification basis and with a degree of compression quite foreign to the rest of the book. Surely there is sufficient clinical evidence of the value of surgery of the sympathetic system to justify the allotment of more than two pages to this subject?

The authors would appear at times to be lacking in a sense of clinical balance; thus six different methods of performing partial gastrectomy are spoken of, but the treatment of acute intestinal obstruction is dismissed in less than a page, and surely it is in the province of a text-book to discuss treatment rather than operative detail? As additional space has been required for chapters on new subjects, some of it could have been spared in the chapter on amputations (which still contains much that is obsolete), even if operations of historic interest, which one scarcely expects to be included in text-books, were not taken into account. It is hoped that in the next edition the authors will use the blue pencil unsparingly both in the elimination of letterpress and of figures of subjects of no clinical importance, such as those of mammary hypertrophy or one of malignant pustule, which would not suggest the disease in question to anyone of wide acquaintance with it.

In spite of these defects, which are possibly those of any text-book passing rapidly through several editions, the work aims at and attains a high level, which is probably unsurpassed by that of any other modern text-book in the English language. Nevertheless, the authors, by taking their courage in their hands and excluding any prolonged description of conditions which they had never seen in their own hospital for the last ten years, would have found that they had saved sufficient space to devote more pages to subjects of increasing clinical interest, and probably also to reduce the two volumes appreciably in size.

Idols and Invalids. By JAMES KEMBLE, Ch.M., F.R.C.S. Crown 8vo. Pp. 212 + x. 1933. London: Methuen & Co. Ltd. 6s. net.

MR. KEMBLE has collected together a series of essays, some of which have already appeared in various magazines. His object is to explain on medical grounds the conditions which have modified the lives and actions of some persons known to history. The results of his inquiries are often interesting, although they will not always be accepted by his fellow-historians. The most satisfactory essay perhaps is that dealing with Judge Jeffreys, who was born in 1648 with so brilliant a brain that he became Lord Chief Justice at the age of 35. Two years later his character changed rapidly for the worse, and in 1685 he presided at the Bloody Assizes which have handed his name down in infamy. Mr. Kemble quotes a letter written from Dorchester during the Western Circuit, in which he says, "I am so tortured with the stone as to have to make use of my servant's pen to give a relation of what has happened since I came here." The pain of the vesical calculus, coupled with an acute cystitis increased by long journeys over the rough roads of the West Country, was, Mr. Kemble thinks, a sufficient explanation of the outbreaks of temper and the monstrous judicial interruptions which marked the trials at Salisbury, Exeter, Taunton, Bristol, and Wells. The explanation is plausible and probably correct.

The essays on Columbus and King Henry VIII are more open to criticism. Mr. Kemble thinks that the mental symptoms from which Columbus is known to have suffered late in life were associated with G.P.I. He accepts without demur the general belief that Henry VIII was syphilitic, but this essay seems to have been written before the publication of Mr. Fredrick Chamberlin's painstaking study of the private character of Henry VIII.

There are interesting accounts of Byron, of Louis XV, of the Borgias, of Cleopatra, of Nelson, and of Queen Anne. The book ends with some extracts from Ramazini's *Treatise on Diseases of Tradesmen* translated into English in 1746. It is an early treatise on occupational diseases.

Urology in Women. A Handbook of Urinary Diseases in the Female Sex. By E. CATHERINE LEWIS, M.S. (Lond.), F.R.C.S., Surgeon, Royal Free Hospital, London. Large 8vo. Pp. 76 + viii, with 21 plates and 4 illustrations in the text. 1932. London: Baillière, Tindall & Cox. 6s. net.

THE authoress states in the preface that this little book is not intended to be a complete treatise on urology, but rather to emphasize certain points which have a particular application in women patients. She has succeeded admirably, for the book is pleasantly written, well printed and illustrated, light enough to read in an easy chair, and published for the unusually low price of six shillings. We are sure that there is a definite opening for such monographs, if only for reading on a railway journey.

There are some faults in the book, owing perhaps to the authoress's commendable efforts to make it readable; thus on page 27 she writes of repeating an examination on a *sterile* specimen of urine when she almost certainly means one that has not been contaminated; and when she refers to a growth of the urethra as being "either comparatively innocent or suspiciously rank in appearance", she makes use of a description which is likely to cause acute pain to a sensitive mind. In the article

on cystic dilatation of the vesical end of the ureter we think she confuses two separate conditions—cystic dilatation and prolapse, which have been shown by Mercier to be quite distinct. We note that there is no mention of his article in the short bibliography appended to each chapter.

In spite of these slight shortcomings, we congratulate Dr. Catherine Lewis on producing such an excellent monograph, and, we repeat, one that is eminently readable—an uncommon accomplishment nowadays.

Surgical Operations. A Textbook for Students and Nurses. By E. W. HEY GROVES, M.D., B.Sc., M.S., F.R.C.S., Consulting Surgeon, Bristol General Hospital, etc. Third edition. Royal 8vo. Pp. 263 + viii, with 204 figures in the text and an appendix illustrating instruments. 1933. London: Humphrey Milford. 18s. net.

THE project of writing a text-book of operative surgery, which should be of sufficient scope to be valuable to medical students and not so weighted with detail as to be too voluminous for the training of surgical nurses, must have been no easy task, but that the author has been successful is evidenced by the appearance of a third edition within fourteen years.

It is clear from the plan on which each operative procedure is based that the volume is mainly written for the use of surgical nurses, and in this respect the paragraphs in each section containing a short account of the reasons for the performance of any particular operation should be most helpful. Apart from the indications for operation, the volume contains information which should be of value to House Officers as well as nurses; this particularly applies to the section on the after-treatment of abdominal cases. We find the diagrams illustrating the operation of circumcision more accurate and more helpful than the written description.

The 'grid iron' is the only incision described for the removal of the appendix. We should judge that a right paramedian laparotomy is far the commonest method of abdominal approach; this, though referred to among abdominal incisions, is not described in detail. Surely the N or Z stitch is to be preferred to a simple purse-string around the base of the appendix, and should not this suture be inserted before the appendix is cut off?

The figure depicting stages in the various operations are in general accurate and helpful; these include an unusual number of instruments, and further an appendix of nearly forty pages is devoted to an alphabetical catalogue of most of the instruments in general use.

It is a pleasure to express one's satisfaction with the type and spacing of the sections.

La Phrénicectomie. By L. BÉRARD, Professeur de Clinique chirurgicale à la Faculté de Médecine de Lyon; F. DUMAREST, Médecin en chef du Sanatorium Mangini à Hauteville; and DESJACQUES, Chirurgien des Hôpitaux de Lyon. Royal 8vo. Pp. 114, with 19 figures and 17 plates. Paris: Masson et Cie. Fr. 30.

THE operation of phrenicectomy has attained to such world-wide usage within the last ten years that one welcomes a book on this subject written jointly by these authors so competent to deal with the subject.

In *La Phrénicectomie*, L. Bérard, F. Dumarest, and Desjacques review the whole subject of phrenicectomy and phrenic evulsion and the influence of this operation on pulmonary tuberculosis in a thorough and well-balanced manner, based on their experience in nearly 700 cases. They are strong advocates of the operation in properly selected cases; but they sound repeated warnings that the operation is not without its risks, that certain unsatisfactory after-effects may develop, and that, if due care is not taken in the selection of the case and the carrying out of the operation, the patient may lose instead of profiting by it.

After a brief historical review, the anatomy of the phrenic nerve and of its accessory branches is detailed, and the physiological functions of the diaphragm are considered. The authors mention the variations in technique for ensuring destruction of the nerve-supply to the diaphragm and describe fully their own method.

They approach the nerve through the more usual transverse incision and expose the nerve mainly by blunt dissection. Their object is to evulse the nerve, and they hold that at least 8 to 10 cm. of the phrenic should be excised, and that this is sufficient to ensure permanent paralysis of the hemidiaphragm. The wound is invariably drained for twenty-four hours. The stages of the operation are illustrated by a series of drawings; that shown in Fig. 14 of the nerve with the divided branches to the sympathetic and of accessory phrenics within the first few centimetres of the division is an ideal not often obtained. Unfortunately no figures are given of the proportion of cases in which there was failure to produce complete paralysis, nor in which there was later recovery of the muscle.

Despite their preference for evulsion, they consider that the radical operation is indicated in certain well-defined conditions (p. 54).

Chapter V is devoted to the accidents and complications of phrenicectomy, and should be read carefully by all who look on the operation as a trivial one. The suggestion made that if the nerve breaks during evulsion at a point 3 to 4 cm. from the division, the distal end should be sought for, is, however, to invite trouble even for the experienced surgeon.

In the succeeding chapter on post-operative treatment, stress is laid on the importance of rest, and attention is drawn to the value which may result if the patient is kept flat or even with the feet raised. In this position the dome normally ascends higher into the thorax.

The indications for phrenicectomy are well set out, as also are the contra-indications. Phrenicectomy is discussed as an independent operation. Its relative advantages in comparison with and as an alternative to artificial pneumothorax are fully considered. The advantage of phrenicectomy in combination with pneumothorax and with other operations, of the temporary paralysis of the nerve, and of bilateral phrenicectomy are also dealt with. No reference, however, is made to the value of phrenicectomy for the treatment of symptoms other than hæmoptysis.

The authors end with the note of warning: "We think that phrenicectomy is not as inoffensive as one is led to believe, and that there are still unknown factors in its mode of action which must be taken into consideration."

There are a few radiographs of cases which are not particularly impressive.

A Clinical Study of the Abdominal Cavity and Peritoneum. By EDWARD MEAKIN LIVINGSTON, B.Sc., M.D., Associate Visiting Surgeon, Bellevue Hospital, New York. Imperial 8vo. Pp. 866 + xxii, with 372 illustrations. 1932. New York: Paul B. Hoeber Inc. $15.00.

IN this book the author has compiled a comprehensive review of abdominal symptoms and signs with special reference to the embryological, anatomical, and physiological factors concerned. The work is intended for students or graduates, and by its arrangement can easily be used to a good purpose by either.

Of the many sections, those dealing with the nervous mechanism of the abdomen—both motor, sensory, and sympathetic—are perhaps the most striking; these chapters are freely illustrated with useful and informative charts and diagrams. In the final chapter on the clinical interpretation of viscero-sensory phenomena a full and careful estimation is given of the value of the various sensory skin manifestations in intra-abdominal affections. As a work of reference the book will undoubtedly serve a useful purpose.

Sixth International Congress of Military Medicine and Pharmacy and Meetings of the Permanent Committee, The Hague, Netherlands, June, 1931. Report of Commander WILLIAM SEAMAN BAINBRIDGE, M.C.F., U.S.N.R., for the Delegation of the United States of America. Medium 8vo. Pp. 167 + xii. 1933. Washington: U.S. Government Printing Office. $1.00.

ALL those who have taken part in one of these International Congresses will appreciate the work done by Commander Bainbridge in giving in compact form a synopsis of the communications and the conclusions reached on the various subjects discussed.

Over thirty countries took part in the Congress, and the average English professional man finds great difficulty in following the discussions in such a wide diversity of languages ; hence the value of this report, which in a small volume of 166 pages embodies most that is important in the debates which in the original official report occupy 763 pages.

We have heard it said that these International Congresses resemble the building of the tower of Babel with a confusion of tongues and no conclusion.

This, however, only refers to the papers and debates, and there is no doubt that the military medical services of all countries have derived much knowledge of the methods adopted by other countries to deal with sick and wounded in war since these bi-annual congresses were inaugurated. But of even greater value is the personal contact with the leaders in military medical matters of all the countries concerned.

The only weak point in Commander Bainbridge's report is the lack of reference to the various demonstrations which are always a feature of these Congresses.

The exhibition of Field Medical Units, instruments and appliances, and visits to military hospitals and establishments give the visitor a better idea of the methods adopted in a particular country than the papers read and the discussions which follow.

At this Congress, held in 1931 at The Hague, five subjects were put up for discussion.

I. The recruiting, training, and advanced training of military medical officers and pharmacists.
II. The psychoneuroses of war : the immediate and remote effect of war on the nervous system of combatants and non-combatants.
III. Methods of hæmostasis on the battlefield : standardization of first aid material and the mode of application.
IV. The preparation and storage of medicinal ampoules in use in the naval and military medical services.
V. The sequelæ of war wounds of the teeth and inferior maxilla : their treatment.

In this country we are all aware of the difficulty experienced since the great war in attracting suitable and sufficient young medical officers to the fighting services. These difficulties would appear to be just as great in other countries.

While some of the nations advocated the taking over of the complete medical education of students designed for the Services, from the outset of their career, so that the importance of military problems would be constantly kept in view, the majority were agreed that it is better for the officer to obtain a civil qualification first and then undergo a period of special training in the application of his knowledge to service conditions in peace and war.

The latter method, which is adopted in this country, is undoubtedly the correct one.

All were agreed that the low emoluments of military surgeons were the great bar to getting candidates.

In this country we have no corps of pharmacists such as exists in most continental armies.

These pharmacists form a highly trained body of commissioned officers who are not only responsible for all questions of medical and surgical supply but who also undertake analysis, supply sera, and carry out disinfection.

In the British Army much that is done by the pharmacist is the province of our pathological and hygiene departments.

While we are never likely to have a similar body in our army the possibility of having a few commissioned pharmacists as advisors and as instructors of our non-commissioned officer dispensers might warrant consideration.

The wish, expressed in the conclusions of the Congress on this subject, that exchange between the medical officers of the various countries should take place is a sound one, but unlikely to be fulfilled until the serious shortage of regular officers is adjusted.

Nothing very new emerged from the discussion on the second subject, and all the points brought out in the conclusions have already been in operation in this country.

Subject three is of more direct surgical interest. All contributors to this discussion laid great emphasis on the dangers of the elastic tourniquet. The result of the conclusions on this matter have borne fruit, and modifications in the training of stretcher bearers and medical personnel have been adopted.

Subject four was of special interest to the pharmacists. In our army we rely largely on the trade for medicinal products put up in ampoules.

The fifth subject provided an interesting and important discussion, and although few new points were raised, all speakers stressed the necessity of team work between surgeon and dentist when dealing with facio-maxillary injuries and the establishment of definite centres both in the fighting area and at home for the treatment of such cases.

This was recognized by this country early in the great war, and all the recommendations put forward have been adopted already by us—in fact the conclusions are based largely on our system.

The report has a short foreword from the Surgeon-General, U.S. Army.

It can be recommended as a correct and useful account of the proceedings of the Congress, and should find a place in the library of all those who are interested in military medical and surgical problems.

BOOK NOTICES.

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]

Modern Aspects of Gastro-enterology. By M. A. Arafa, M.R.C.P. (Lond.), Medical Assistant to Guy's Hospital, etc. With a Foreword by Arthur F. Hurst, M.D., F.R.C.P., Senior Physician, Guy's Hospital. Large 8vo. Pp. 374 + xviii, with 79 illustrations. 1933. London: Baillière, Tindall & Cox. 27s. 6d. net.

A Synopsis of Surgery. By Ernest W. Hey Groves, M.S., M.D., B.Sc. (Lond.), F.R.C.S., Consulting Surgeon to the Bristol General Hospital, etc. Tenth edition. Crown 8vo Pp. 693 + viii, with 163 illustrations. 1933. Bristol: John Wright & Sons Ltd. 17s. 6d. net.

Peripheral Nerve Injuries. By Lewis J. Pollock, M.D., Professor of Nervous and Mental Diseases, North-western University, etc.; and Loyal Davis, M.D., Professor of Surgery, North-western University, etc. Imperial 8vo. Pp. 678 + xx, with 312 illustrations. 1933. New York: Paul B. Hoeber Inc. $10.00.

Intracranial Tumours Roentgenologically Considered. By Loyal Davis, M.D., Ph.D., F.A.C.S., Professor of Surgery, North-western Medical School. Vol. XIV of Annals of Roentgenology, edited by James T .Case, M.D., Professor of Roentgenology, North-western University. Large post 4to. Pp. 277 + xviii, with 135 illustrations. 1933. New York: Paul B. Hoeber Inc. $10.00.

Die kombinierte Enzephal-Arteriographie. By Prof. Dr. W. Löhr and Prof. Dr. W. Jacobi (Magdeburg). Imperial 8vo. Pp. 83, with 75 illustrations. 1933. Leipzig: Georg Thieme. Paper covers, M. 16; bound, M. 18.

Der Bandschaden des Kniegelenks. By Dr. Karl Gebhardt (Munich). Medium 8vo. Pp. 59, with 21 illustrations. 1933. Leipzig: Johann Ambrosius Barth. RM. 4.50.

Surgery of the Thorax. By T. Holmes Sellors, M.Ch., M.A., B.M. (Oxon.), F.R.C.S., Assistant Surgeon to Queen Mary's Hospital for the East End, etc. With a Preface by R. A. Young, C.B.E., M.D., F.R.C.P. Demy 8vo. Pp. 519 + xxv, with 140 illustrations, including 11 plates in colour. 1933. London: Constable & Co. Ltd. 22s. 6d. net.

Demonstrations of Physical Signs in Clinical Surgery. By Hamilton Bailey, F.R.C.S., Surgeon, Royal Northern Hospital, etc. Fourth edition, revised and enlarged. Large 8vo. Pp. 287 + xx, with 335 illustrations, some of which are in colour. 1933. Bristol: John Wright & Sons Ltd. 21s. net.

Vorbeugung und Bekämpfung der Operationsgefahren. By Prof. Dr. M. KAPPIS (Hannover). Royal 8vo. Pp. 382 + xii, with 12 illustrations. 1933. Leipzig: Georg Thieme. Paper covers, M. 17; bound, M. 18.60.

Radium: Production, General Properties, Therapeutic Applications, Apparatus. Demy 8vo. Pp. 346, illustrated. 1933. London: Chemical Service Co. Ltd., Sunic House, Kingsway, W.C.2.

Die Bluttransfusion in Theorie und Praxis. By Dr. Med. HANS WILDEGANS, A. O. Professor für Chirurgie an der Universität Berlin. Medium 8vo. Pp. 157 + iv, with 36 illustrations. 1933. Berlin: Julius Springer. RM. 9.60.

Précis d'Anatomie pathologique. By GUSTAVE ROUSSY, Professeur à la Faculté de Médecine de Paris; ROGER LEROUX and CHARLES OBERLING, Professeurs agrégés à la Faculté de Médicine de Paris. Large post 8vo. Two volumes. Pp. 1344, with 582 illustrations and 4 coloured plates. 1933. Paris: Masson et Cie. Paper covers, Fr. 160; bound, Fr. 175.

The Diagnosis and Treatment of Postural Defects. By WINTHROP MORGAN PHELPS, B.S., M.D., M.A., F.A.C.S., Professor of Orthopædic Surgery, Yale University, etc.; and ROBERT J. H. KIPHUTH, Assistant Professor of Physical Education, Yale University. Royal 8vo. Pp. 180 + xiv, with 108 illustrations. 1933. London: Baillière, Tindall & Cox. 23s. net.

Papers Relating to the Pituitary Body, Hypothalamus, and Parasympathetic Nervous System. By HARVEY CUSHING, Professor of Surgery (Emeritus), Harvard University, etc. Large 8vo. Pp. 234 + viii, with 99 illustrations. 1933. London: Baillière, Tindall & Cox. 29s. net.

Roentgenographic Studies of the Urinary System. By WILLIAM E. LOWER, M.D., F.A.C.S., Chief of Department of Urology, Cleveland Clinic, etc.; and BERNARD H. NICHOLS, M.D., F.A.C.R., Chief of Department of Roentgenology, Cleveland Clinic. Imperial 8vo. Pp. 812 + xviii, with 812 illustrations. 1933. London: Henry Kimpton. 84s. net.

Atlante di Chirurgia dello Stomaco. By G. EGIDI. Large 8vo. Pp. 15, with 30 plates. 1933. Rome: Luigi Pozzi. L. 35.

The Cure of Hæmorrhoids, Varicose Veins and Ulceration, and Allied Conditions: by Modern Methods and Bandaging. By STUART MCAUSLAND, B.A. (Lond.), M.D., Ch.B. (Liv.), M.R.C.S., L.R.C.P., Hon. Physician, Hahnemann Hospital, Liverpool, etc. Large 8vo. Pp. 63. Illustrated. 1933. London: John Bale, Sons and Danielsson. 3s. 6d. net.

Operative Surgery. By WARREN STONE BICKHAM, M.D. and Phar. M. (Tulane), M.D. (Columbia), F.A.C.S., Former Surgeon in charge of General Surgery, Manhattan State Hospital, New York, etc.; and CALVIN MASON SMYTH, jun., B.S., M.D., F.A.C.S., Assistant Professor of Surgery, Graduate School of Medicine, University of Pennsylvania, etc. Vol. VII, The Newest Operations and General Index. Royal 8vo. Pp. 849 + viii, with 765 illustrations. 1933. Philadelphia and London: W. B. Saunders Co. 55s. net.

Die Bruchoperation nach Bassini. By Dr. ATTILIO CATTERINA, O.-O. Professor der chirurgischen Operationslehre an der kgl. Universität in Genua. Large crown fo. Pp. 56, with 16 coloured plates by HORATIUS GAIGHER, Doktor der gesamten Heilkunde. 1933. Berlin and Vienna: Urban and Schwarzenberg. RM. 12.

Hirnchirurgie: Erfahrungen und Resultate. Edited by Dr. HANS HOFF and Dr. LEOPOLD SCHÖNBAUER (Vienna). Royal 8vo. Pp. 472 + vi, with 238 illustrations. 1933. Leipzig and Vienna: Franz Deuticke. Paper covers, M. 40; bound, M. 43.

The Injured Workman. By G. F. WALKER, M.D., M.R.C.P., with the collaboration of J. HARVEY ROBSON, Barrister-at-Law (Law); R. E. JOWETT, M.D., Ch.B., D.L.O. (Ear, Nose, and Throat Surgery); STANLEY RITSON, M.B., M.S., B.Sc., F.R.C.S. (General Surgery); JOHN FOSTER, M.A., M.B., F.R.C.S., D.O.M.S. (Ophthalmic Surgery). Foreword by W. H. MAXWELL TELLING, M.D., B.S., F.R.C.P., Professor of Forensic Medicine, University of Leeds. Crown 8vo. Pp. 190 + xx. 1933. Bristol: John Wright & Sons Ltd. 6s. net.

The Digestive Tract. A Radiological Study of its Anatomy, Physiology, and Pathology. By ALFRED E. BARCLAY, O.B.E., M.A., M.D., D.M.R.E., Lecturer in Medical Radiology, University of Cambridge. Large 8vo. Pp. 395 + xxviii, with 275 illustrations. 1933. Cambridge: University Press. 36s. net.